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THE
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OF
THE MARINE BIOLOGICAL STATION
OF ASAMUSHI
TÔHOKU UNIVERSITY

Vol. VII, Nos. 2, 3, 4

(March, 1955)

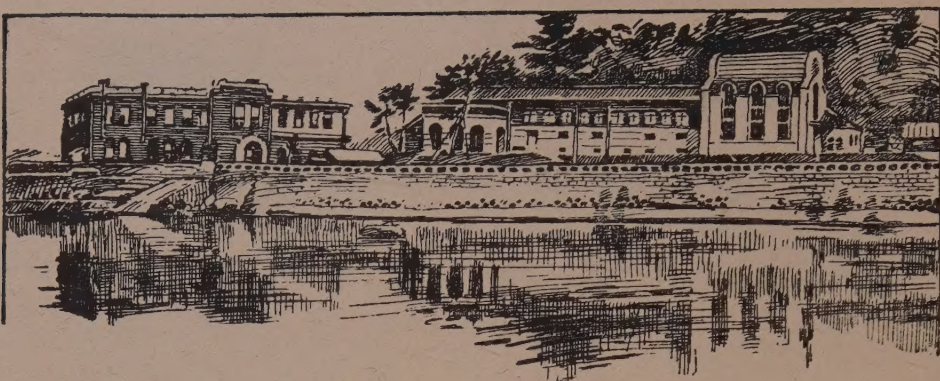
MEMORIAL NUMBER
FOR THE
THIRTIETH ANNIVERSARY



Asamushi, Aomori Prefecture
JAPAN

東北大學附屬臨海實驗所

青 森 縣 淺 虫



ANNOUNCEMENT

The Change of the Japanese Title of the Journal

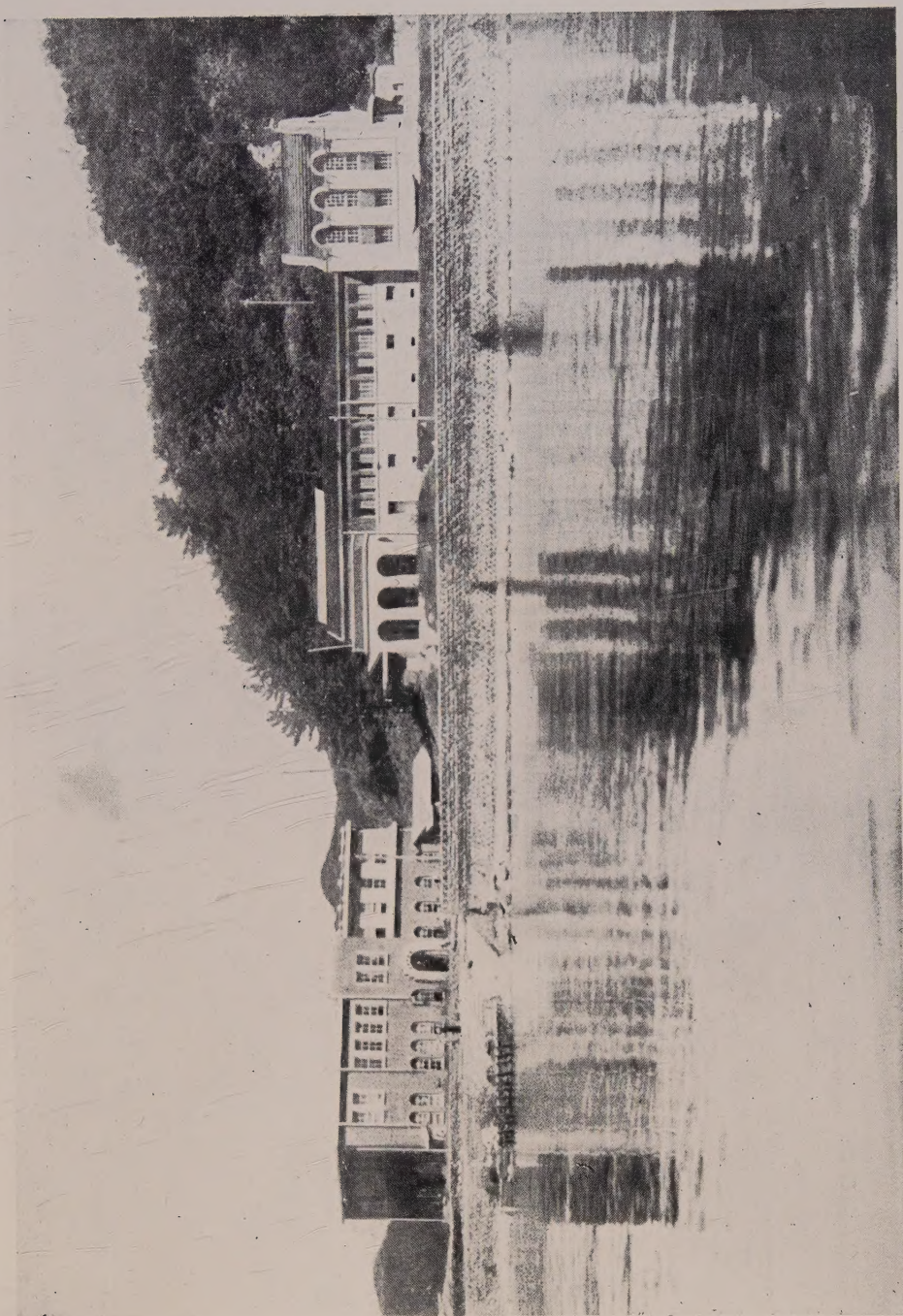
This journal has been published under the Japanese title "Kaiyô Seibutsu Jihô" ("The Journal of Marine Biology"). This title, however, expresses nothing proper to the Tôhoku University, to which the Station belongs, or to Asamushi where the Station is situated, while the English title "The Bulletin of the Marine Biological Station of Asamushi" seems more appropriate. The Japanese title has, therefore, been changed "Asamushi Rinkai Jikkenjo Hôkoku" in accordance with the English title. The latter will remain unchanged. The series of the new title will succeed the number of the volume of the previous series.

It may also be announced, by the way, that contributions from the Marine Biological Station have been numbered only when published in the Science Reports of the Tôhoku University (Biology), but those which will be published in this journal will also be numbered hereafter.

本紙改題に就いて

本誌は従来（海洋生物時報）なる誌名を以て刊行されて来たが、此の名称は本実験所の所属する東北大学或は所在地浅虫の何れを示す文字をも含まず従つてその個性を端的に表はさない恨があつた。且つ英文名ともその意義の一致を欠いていた。依つて此度英文名とも一致する表記の題名〔浅虫臨海実験所報告〕と変更した次第である。巻号数は従来海洋生物時報の巻号数を継承することにした。

因に本実験所業績の番号は従来東北大学理科報告（生物学）に発表の論文にのみ附してあつたが、今後は本誌に発表の論文にも番号を附することにした。



Laboratory
研究室

Aquarium
水族館

The Marine Biological Station of the Tôhoku University
東北大学附属海実験所



Plan of Grounds and Buildings.
敷地及び建物平面図

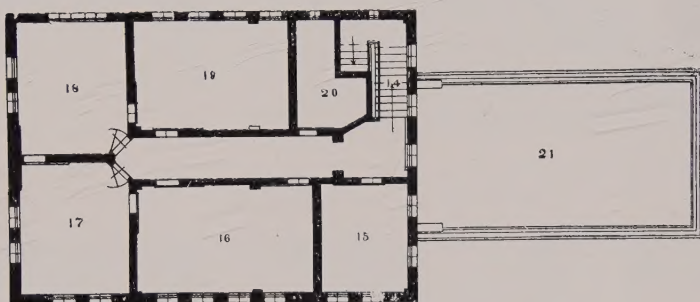


Location of Asamushi
浅虫の位置略図



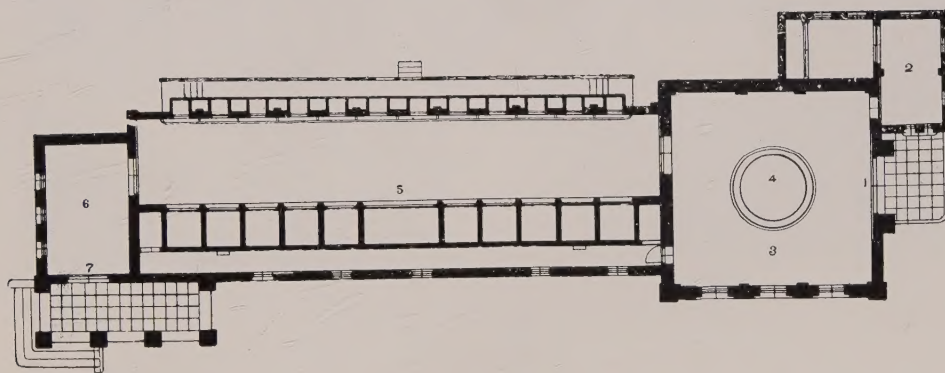
Ground floor of the Laboratory.

研究室一階



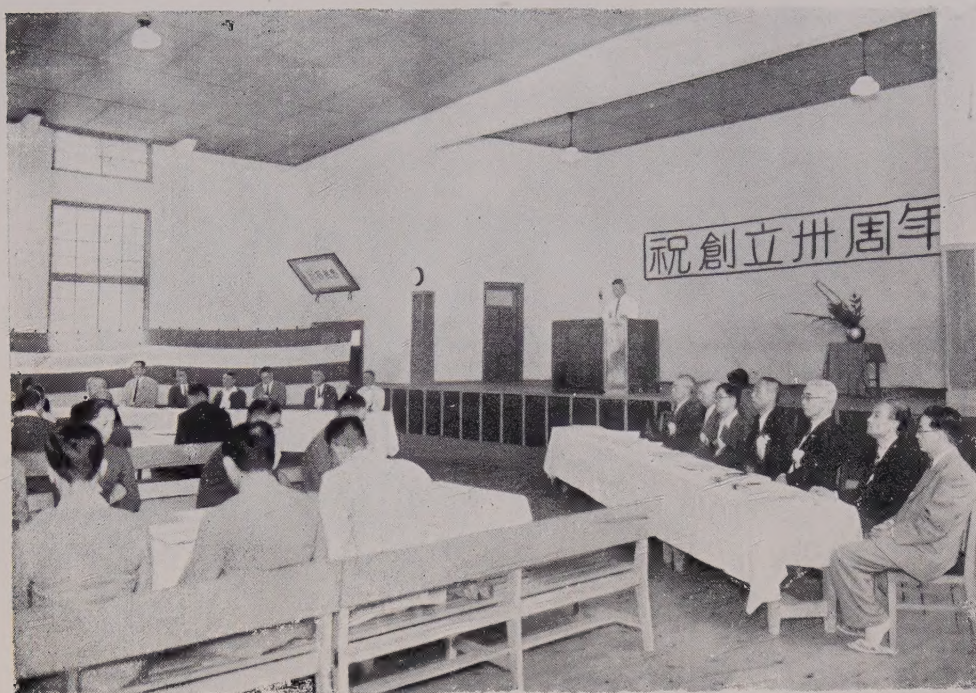
First floor of the Laboratory.

研究室二階



Aquarium.

水族館



The President of the University giving congratulatory address.
 本学総長祝辞朗読



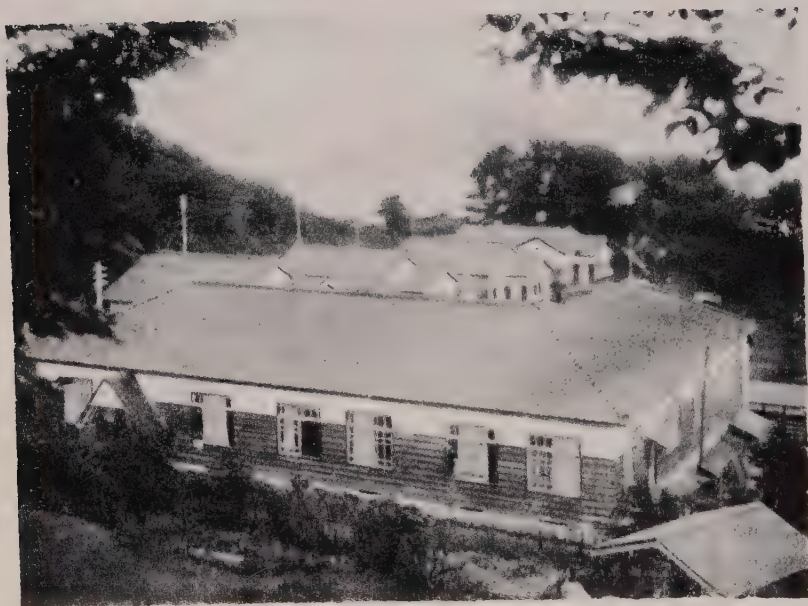
The Guests and the Staff of the Marine Biological Station.
 来賓及び実験所幹部



Professor Emeritus Dr. Shinkishi Hatai
名誉教授 畑井新喜司先生



Aquarium.
水族館内部



Dormitory and Official Residences.
寄宿舎及び官舎

THE THIRTIETH ANNIVERSARY OF THE
MARINE BIOLOGICAL STATION OF ASAMUSHI
TÔHOKU UNIVERSITY

By

SHICHIROKU NOMURA

野村七録

Director of the Marine Biological Station
Professor of Zoophysiology at the Biological Institute
Tôhoku University

The Marine Biological Station of Asamushi, Tôhoku University was inaugurated on July 5th, 1924 (the thirteenth year of Taishô Era), and thirty years have elapsed since then. The Station was established as an extension of the Biological Institute, Faculty of Science, Tôhoku Imperial University and was intended primarily for the instruction of the students and research work of the staff. During the three decades more than three hundred students have been instructed here, and many of them found themselves eminent professors or able investigators and are occupying important positions in the field of biology in Japan. A great deal of investigations have also been accomplished here by the staff of the Station and the Biological Institute, and also by outside investigators who could enjoy the study at the Station. A large number of contributions from the Station have been published and distributed widely not only in the country but also to leading laboratories and institutions all over the world and highly appreciated. In this way the Station has attained its eminent position among the biological stations of the world and acquired a wide reputation. We may be right in believing, therefore, that the establishment of the Marine Biological Station at Asamushi have been quite successful. The staff of the Station considered that the celebration of the Thirtieth Anniversary of the Station might be splendid, and we have made effort to arrange a program as pleasant as possible. The celebration was held in two parts.

The Internal Celebration of the Anniversary. First, the anniversary was celebrated just on the day of the anniversary, July 5th, 1954, at the Station, and only the members of the Station and the students who were undergoing their summer courses there, sixty persons altogether, participated in it. This was because the space of the Station did not permit us to invite a large number of

outside guests.

We assembled on the roof of the laboratory building, and the commencement of the ceremony was announced by Dr. Hirai. The congratulatory speeches were made by the Director of the Station, and Dr. Katô and Mr. Hiwatashi (representing Prof. Motomura, who was then on his journey to U. S. A.). After the ceremony, a luncheon party was given at the tea-house "Miharashi" on a nearby hill, and "sekihan (rice boiled with red beans and served usually on auspicious occasions) and other delicacies were served and enjoyed very much. Several speeches and free talking went on cheerfully. In the afternoon, base ball matches were made by the junior versus the senior students and by the teachers of the Asamushi Middle School versus MBS. The seniors and the Middle School won the day. After supper, the students held "compa" in the dining room of the dormitory, and the staff were also invited. Congratulatory "sake" was served by the Association in Support of the Celebration, and followed speeches, chats, and songs pleasantly, and the program of the day closed in a great success.

The General Celebration of the Anniversary

This part of celebration was held on August 20th, 1954, and the subsequent days, with support of the authorities of Aomori Prefecture and Asamushi Village, to which we have the pleasure of expressing our cordial thanks at this opportunity. The program of the celebration was manifold and ran as follows:—

August 20

1. Ceremony Asamushi Middle School, 10 a. m.
2. Luncheon Party " " "
3. Banquet Tôôkwan Hotel, 6 p. m.
4. Cinema Show Asamushi Middle School, 7. 30 p. m.
 - a. Preparation of Magnesium from Sea Water
 - b. Shell Gathering at Ebb Tide
 - c. Antarctic Fairyland (Colour film)

August 21

5. Memorial Popular Lectures
 - At Nowaki Middle School, Aomori, 2.00 p. m.
 - a. Sea and Food Prof. T. Imai (Fisheries Department)
 - b. Aomori Prefecture in the History of Japan
Prof. R. Furuta (Faculty of Literature)
 - c. Cinema Show: Search for Japanesque Beauty
Nanuku in the North
 - At Asamushi Middle School
 - d. Life of Insects Prof. M. Katô (Biological Institute)
 - e. Bewitching Animals
Prof. T. Nagano (Second College of Arts and Sciences)

August 20 to 22

6. Aquarium Free Admittance, day and evening

August 21 to 22

7. Exposition of the Laboratory

August 21

- (Fireworks Display) At Asamushi, under the auspices of the Tourist Association

A brief comment may be added to the program.

The commencement of the ceremony was announced by Asst. Prof. Hirai, and the Director

of MBS gave a ceremonial address, acknowledging the presence of all the participants at the ceremony and their coordination and supports given for the development of the Station and also for the celebration of the anniversary, and complimented on the history of the Station, and wished its further prosperity.

Letters of thanks and memorial gifts (chests of "Tsugaru-nuri" lacquer wares) were donated to Professor Emeritus Dr. S. Hatai, founder and first director of the Station, and Professor Emeritus Dr. S. Kokubo, ex-Director of the Station, by the hands of the President of the University, Dr. S. Takahashi. Testimonials of commendation and memorial clocks were presented to Messrs. Tomegorô Moriyama and Sakujirô Takahashi, for their faithful service for long years, by the hands of the Director. Ten lovely pupils of Asamushi Primary School, representing the group who had co-operated to keep clean the surroundings of the Aquarium, also were awarded likewise a letter of thanks and memorial gifts (applause).

Then were given congratulatory addresses by the following notables :

1. Minister of Education (read by Prof. Takatsuki, College of Education, Tokyo)
2. President of the Tôhoku University, Dr. S. Takahashi.
3. President of Hirosaki University, Dr. K. Kôriba.
4. Governor of Aomori Prefecture, Mr. B. Tsushima. (read by Vice-Governor)
5. President of Prefectural Assembly, Mr. S. Nakajima.
6. Member of the Diet, Mr. I. Yamazaki.
7. Member of the Diet, Mr. Y. Awaya.
8. Village Headman, Mr. I. Akasaka.

It was also announced that congratulatory telegrams were received from the President of the Yamagata University, former members of MBS: Messrs. Kawamura and Matsuya, Prof. Motomura on his journey to U. S. A., and Dr. Tuge, and others. The ceremonial part of the program closed at noon, and the luncheon party began at 0.30 p. m. The Director extended the opening greetings to the attendance thanking their presence and support in the celebration, especially the contribution of the local people. Congratulatory addresses were delivered by Prof. emer. Dr. Hatai and Prof. emer. Dr. Kokubo and were much applauded. Dr. Kôriba, President of Hirosaki University proposed to drink a toast to the celebration of the anniversary and all the participants followed him, crying "Banzai" threetimes. For a while, all the attendance chatted cheerfully and enjoyed the lunch with "sekihan" and other dainties in chip-boxes, accompanied by bottle of *sake*. The bottle and cup for *sake* were especially designed for the celebration and everyone could take them home as a souvenir. After-dinner speeches were given by outstanding persons and concluded by Prof. Watanabe, dean of the Faculty of Science. All the people seemed much delighted and satisfied and the party closed in a great success at two o'clock. Speeches were registered by a tape-recorder. Letters of invitation to the occasion had been sent out to one hundred and ninety five persons and ninety five of them attended.

In addition to the affairs above-mentioned, cinema show was given in the evening, 7.30 p. m., at the Asamushi Middle School. About 800 juniors, mainly pupils and students, enjoyed the picture.

Besides the cinema show for juniors, a banquet was given for senior and distinguished persons at 6.00 p. m. at Tôdôkwan Hotel. The banquet commenced with the salutation of Prof. Watanabe, dean of the Faculty. Thirty four persons following were present :

- Dr. K. Kôriba (President of Hirosaki University)
- Dr. J. Tokita (Dean of Fisheries Faculty, Hokkaido University)
- Mr. T. Yokoyama (Vice-Governor of Aomori Prefecture)
- Mr. Z. Kodate (Painter, member of Kokuga-kai)
- Mr. T. Mori (Principal of Asamushi Middle School)

Mr. T. Hiratá (Director of Tôôkwan Hotel)
 Mr. I. Akasaka (Village Headman of Asamushi)
 Prof. emer. Dr. S. Hatai (Founder of MBS)
 Prof. emer. Dr. S. Kokubo (ex-Director of MBS)
 Prof. S. Takatsuki (College of Education)
 Prof. S. Kobayashi (Kyoto College of Textile-Fibre Industry)
 Prof. H. Tuge (Hôsei University)
 Prof. N. Abe (Faculty of Agriculture, Yamagata University)
 Prof. Sh. Kobayashi (Fisheries Faculty, Hokkaido University)
 Prof. S. Ishida (Faculty of Science and Literature, Chiba University)
 Prof. M. Toriumi, (Hiroshima Women's College)
 Dr. S. Takahashi (President of Tôhoku University)
 Prof. M. Watanabe (Dean of Faculty of Science, ")
 Prof. R. Furuta (Faculty of Literature, Tôhoku University)
 Prof. T. Imai (Faculty of Agriculture, Tôhoku University)
 Prof. T. Nagano, (Second College of Arts and Sciences, ")
 Prof. A. Kimura (Biological Institute, Tôhoku University)
 Prof. T. Jimbo (" " " ")
 Prof. M. Nagao (" " " ")
 Prof. M. Katô (" " " ")
 Asst. Prof. R. Sato (Fisheries Dept., " ")
 Asst. Prof. G. Tomita (Biological Institute, " ")
 Asst. Prof. G. Yamamoto (" " " ")
 Lecturer K. Hiwatashi (" " " ")
 Mr. E. Uchida (Director of Administration Bureau, " ")
 Mr. T. Saganuma (Chief of General Affairs Section, " ")
 Mr. K. Soga (Secretary of the Faculty of Science, " ")
 Mr. F. Konno (Chief of the General Affairs Subsection, ")
 Prof. S. Nomura (Director of MBS, Biological Institute " ")
 Asst. Prof. E. Hirai (Resident Administrator, MBS. " ")

In contrast with the ceremony and luncheon party of the day-time, the banquet was informal and made the participants more at home. Congratulatory speeches were made by many attendants, sake was served, Japanese dance and songs were played, making the guests all delightful. The banquet proceeded cheerfully and closed about nine o'clock in a great success.

Meeting of the Alumni. This was held at the Director's residence, in the evening of August 20th, after the banquet at Tôôkwan Hotel, and old boys, some of whom had not seen one another for long years, chatted cheerfully far into midnight, recollecting their good old days at Asamushi. About fifteen members attended.

Memorial Popular Lectures. On Aug. 20, two series of popular lectures were given at the same time at Aomori and Asamushi, by professors of the University. At Aomori, this lecture meeting was held under the co-operative auspices of the Social Education Section of the Prefecture and the Tôô Nippô Press. Prof. Imai of the Fisheries Department began with the history of the Asamushi Marine Biological Station, and proceeded to the story of the marine stations of the world, expeditions of the Challenger, Dana and other explorations of oceans, and concluded with the problems of food and marine resources. Prof. Furuta discussed

the first appearance of Aomori Prefecture in the literature of Japanese history, and stated the vicissitudes of Tsugaru, Hachinohe and Shimokita regions until the Restoration of Meiji. About one hundred and fifty persons were present, mainly students, teachers and some fisheries industrials.

At Asamushi, Prof. Katô gave an interesting account of insect life, mainly of flies and mosquitoes from ecological point of view, frequently quoting "haiku" (seventeen-syllabled verses) in relation to insects. Prof. Nagano gave interesting and amusing stories referring to the badger in the fairy tale. About five hundred persons were present, and the meeting was successful.

Fireworks Display. In the evening of Aug. 21, fireworks were displayed at Asamushi and Yunoshima in celebration of the anniversary under the auspices of the Tourist Association. A great many spectators not only from Aomori, but also from various remote places crowded the village of Asamushi, and all the hotels were packed with guests. The celebration thus drew the attention of all the provincials.

Issue of Memorial Number and Erection of Memorial Arbour. In addition to the manifold program of the celebration above-mentioned, the expenditure for the issue of the present memorial number of the Bulletin of the MBS and the erection of a memorial arbour "Rinkai-Tei" were granted by the Board of Trustees of the Foundation in Support of the Marine Biological Station of the Tôhoku University, to which we wish to take this opportunity to express our cordial thanks. The present number comprises papers and reminiscences of the former directors and members of MBS and investigators, who have once studied marine biology here and majority of whom are old pupils of Prof. emer. Dr. Hatai, founder and first director of the Station, to whom the papers are dedicated.

I have thus far stated affairs in the celebration of the Thirtieth Anniversary of MBS, and it seems to me desirable to give, moreover, on this occasion, a brief description of the Station: its history, present status, activities, etc.

History. The Tôhoku (Imperial) University had projected to open a Biological Institute and a Marine Biological Laboratory for the instruction of students and the promotion of biological investigation. Dr. S. Hatai, then Professor of the Wistar Institute of Anatomy and Biology in Philadelphia, was invited to lay plan of the institutions just mentioned. After a great effort of the then President Dr. M. Ogawa and the staff of the university a government budget for the establishment of the institute and the station was secured.

By the act of the forty-sixth session of the Imperial Diet, in 1923, the government granted 150,000 yen for the establishment of the Marine Biological Station, and moreover, 50,000 yen was donated by Aomori Prefecture for the establishment of the aquarium. The ground of the Station was donated by the late Mr. Jisaburô Nomura, then a member of the Imperial Diet, and the late Mr.

Gizô Hirata, the grandfather of Mr. Tadashi Hirata, owner of Tôôkwan Hotel. (The former made the donation in the names of his mother Bun and his son Ichisaburô) Dr. Hatai and his colleagues, during the years 1921-22, made a thorough survey of the coast of the Tôhoku (North-Eastern) District to find the most suitable site for the Marine Biological Station, and finally Asamushi was found to be the most satisfactory site. The erection of the buildings began in May 1923, and was completed next year.

On July 8th, 1924, The Imperial Ordinance No. 157, was issued denoting that the Marine Biological Station of Asamushi should be attached to the Faculty of Science, Tôhoku Imperial University, the Director of the Station should be appointed by the Minister of Education from among the professors or assistant professors of the Faculty of Science, and the administration of the Station should be carried out by the Director of the Station under the supervision of the President of the University.

The inauguration was held on July 5th, 1924 (the thirteenth year of Taishô Era) on the neighbouring flat, "Senjô-jiki", where the late Great Emperor Meiji had stopped for rest on August 27, 1881, on his Majesty's journey around the Tôhoku District, and a monument now stands in commemoration of this event.

The celebration was attended by the staff of the university and a large number of local dignitaries. Supported by the local co-operations and accompanied by various entertainments, the fête was very lively and successful.

Professor emeritus Dr. Hatai was appointed the first Director of the Station. He laid much emphasis upon investigations, especially of physiology, and numerous important papers by his pupils appeared soon after the opening of the Station, which together with the Biological Institute in Sendai, became the cradle of animal physiology in Japan, and the trend has been kept on to the present.

Dr. Hatai held his position until his retirement on Feb. 28, 1938.

The succession of the directorate has been as follows :

1. Prof. Dr. Shinkishi Hatai (Physiology) 1924-1938
2. Prof. Dr. Sanji Hôzawa (Taxonomy) 1938-1940
3. Prof. Dr. Ekitarô Nomura (Experimental Zoology) 1940-1942
4. Prof. Dr. Shichiroku Nomura (Physiology) 1942-1944
5. Prof. Dr. Sanji Hôzawa (Taxonomy) 1944-1947
6. Prof. Dr. Seiiji Kokubo (Planktology) 1947-1953
7. Prof. Dr. Shichiroku Nomura (Physiology) 1953-1956

I cannot pass without expressing our sorrow for the loss of the second and third directors. Death and retirement have moved all the original members of the Station, and the present director is the only one who has since the establishment been concerned in the history of the Station. It seems, therefore, my duty to record, on this occasion, the history of the Station as far in detail as the

space permits.

The Marine Biological Station of Asamushi has been very active from the beginning and its contributions appeared early in the first number of the Volume I of the Science Reports of the Tôhoku Imperial University, Ser. 4, (Biology), which provisionally was printed at the Wistar Institute Press of Philadelphia, as the printing facilities in Tokyo had been destroyed by the Kwanto Great Earthquake of September 1, 1923. It may be added that Dr. Hatai, the late Dr. E. Nomura and the present writer had already begun research work in the previous summer at the annex of the Tôôkwan Hotel before the opening of the Station, overcoming various inconveniences, showing the zealous activity and hasty disposition of Dr. Hatai.

Communication. Asamushi Railway Station, on the Tôhoku Main Line, can be reached by express trains taking about thirteen and a half hours from Tokyo and seven and a half hours from Sendai. Omnibuses also start from Aomori two or three times every hour during day-time and reach Asamushi in about 45 minutes, wherefrom it takes about 20 minutes on foot (about 2 km.) to MBS. The road is flat and walking is quite easy, and taxi is also available. MBS is situated on the north-east of Asamushi, which is famous for hot spring, and occupies the extremity of a small peninsula projecting westwards from the larger peninsula Natsudomari-Saki, which divides Mutsu Bay into Aomori Bay in the west and Noheji Bay in the east. MBS commands Aomori Bay on the west side and faces a hill on the east. The ground covers about 25,740 sq.m. (7,821.959 tsubo) estimated at 39,480 yen when donated. Three isles of Yunoshima, Gomejima and Mourajima are distributed on the neighbouring sea and expand a picturesque scenery. The sea water is clear and shallow, measuring about 30m. in depth in the neighbourhood. The coast-line here consists mainly of low cliffs and gravelly, rocky and stony beaches and is much indented.

Prof. Guyer of Wisconsin University admires MBS as a splendid modern institution as follows: — "Rarely indeed can the zoologist command a modern, well-equipped laboratory and veritable fairyland of natural enchantment all in one setting, but exactly this combination awaits the scientist who chooses to visit the Marine Biological Station of Asamushi. Situated on the north-eastern coast of the main island of Japan, seventeen hours' rail journey from Tokyo and eight from Sendai, this up-to-date attractive establishment, which compares favorably in equipment with any marine laboratory in the world, offers its hospitality to native and foreigner alike. To speak of the low cliffs, the rocky beaches, the wild, indented shore-line, the mountainous hills which springs abruptly from the sea, the beckoning coves and channels, is but to catalogue the material realities of the place, whereas it is, in fact, an indescribable ethereal quality, which lays hold of the senses when one visits this land of pastel hues, mysterious hazes and cameo-

cut perfections." (M. F. Guyer: Biological Stations in Japan. The Scientific Monthly, 1929, vol. 29, p. 383-393).

The climate is especially favourable for summer work and the place is free from the distractions of ordinary fashionable summer resorts.

Fauna and Flora. Fauna and flora in the neighbourhood are abundant and supply ample materials for instruction and research work. Bottom fauna is also rich, and set-net fisheries are carried on along the coast from May to October, and haul-net fisheries off-shore also proceed, yielding large amounts of marine products.

A comprehensive biological survey of Mutsu Bay was undertaken under the auspices of the Saitô Gratitude Foundation of Sendai, and the fundamental biological knowledge of Mutsu Bay was established.

Equipments and Facilities. The station is composed of the following buildings and equipments:

Laboratory building is a two-storied brick and concrete structure, covering 389 sq.m. (ca. 150 tsubo), divided into 15 rooms and corridors: eight rooms for the staff, two for students, reception room, photographic dark room, library, janitor's room, and biochemical laboratory. There are also a submarine laboratory, marine pool, and a glass house with three concrete tanks for culture and reserving of organisms (tanks cover about 6 tsubo).

Each room is provided with running sea and fresh water and alternating electric current. The pumping station takes the sea water from a point behind the laboratory, where currents and depth insure purity, and the sea water is reserved in two concrete tanks on the hill, from which it is distributed to all the laboratory rooms and aquarium through the lead pipe system, which is believed to discharge practically no toxic substances. One laboratory room downstairs is used mainly for instruction of general zoology and planktology and one upstairs is used for physiology and embryology courses. The library is full of valuable monographs, series and periodicals, domestic and foreign, bought, exchanged and donated. The aquarium house covers about 238 sq.m. and has twenty-four tanks of various sizes. A round pool in the entrance-hall, 2.45 m. in diameter, and 1.36 m. deep, is usually used for marine mammals, when available, or other larger aquatic animals. On the one side of the house, there are eleven tanks, one measuring $2.95 \times 1.41 \times 1.81$ m., with a capacity of 5,657 litres, and the others $1.35 \times 1.41 \times 1.81$ m. holding 2,589 litres respectively. On the other side, there are twelve small tanks, $0.57 \times 0.57 \times 0.60$ m., holding 308 litres respectively and are used for small marine and fresh water animals.

The exhibition of the aquarium to the public begins in May and ends in November every year. The annual total number of visitors to the aquarium amounts to more than 150,000 on the average in recent years. This is believed to contribute

a great deal to popularization of the knowledge of marine biology. The specimen room is a wooden building half-way up the hill, covering about nine tsubo. The specimens comprise not only aquatic forms but also birds collected in the Survey of Mutsu Bay.

Dormitory. The dormitory is a wooden building, covering 363 sq.m. and a part is two-storied. It has ten rooms for the students, a reception room, a dining room, a kitchen, a bath, and two rooms for the janitor and the cook, and can accomodate about fifty persons altogether, and meals are furnished at cost. The Station has in addition five residences for the staff and visiting investigators. The research boat "Kotaka" is of the following qualifications: Length about 8.5 m., tonnage 3, speed 3 miles per hr., 20 HP gasoine motor. She has been active for the three decades, for the routine and research work, collection of materials for instruction and research, and transportation of persons and freights. There are also smaller motor and oared boats, and minor buildings such as warehouses, gasoline store-house, booking box, etc.

The Personnel. The personnel of the Station comprises the following:

Director (additional position): Prof. Dr. Shichiroku Nomura (Zoophysiology,
Biological Institute)

Resident Administrator: Asst. Prof. Dr. Etsuro Hirai (Taxonomy,
Embryology, Planktoloty)

Assistants: Tetsusaburô Okitsu (Planktology)
Bunryû Tsubata (Oceanography)
Saburô Kokubo (Physiology)
Toyoo Aikawa (Physiology)

Five Employees

Instruction. As an extension of the instruction at the Biological Institute in Sendai, summer courses are given every year at the Station, commencing about the beginning of July, and running for one or two weeks respectively. The courses and the staff are as follows:

General Zoology: Prof. M. Katô (Biological Institute)

Planktology: Asst. Prof. E. Hirai (MBS)

Zoophysiology: Prof. S. Nomura (Biological Institute, and MBS)

Embryology: Prof. I. Motomura (Biological Institute)

The courses are intended to supplement the instruction at the Biological Institute in Sendai, and use is made as far as possible of materials available in abundance at Asamushi but not easily obtainable in Sendai and other inland laboratories, and the courses familiarise the students with various aspects of marine biology, and clear the way to wide fields for their future investigations. After the War, the students of other universities of Hirosaki, Yamagata and others also utilize the facilities here. In such cases, instructions are given by the

staff of the Station or by teachers of their own universities.

Investigation. The first Director of the Station, Dr. Hatai, laid much weight on research work from the beginning and this traditional trend has been succeeded up to the present, as was mentioned above. The list of contributions, appended at the end of the present number, shows the results of studies carried out with this traditional spirit during the three decades, overcoming economical and other difficulties. One of the most notable work undertaken by the Station with the co-operation of a large number of biologists in Japan is the Biological Survey of Mutsu Bay, 1926-28, the results of which have appeared in thirty seven papers in the Science Reports of the Tôhoku Imperial University. This accomplishment has contributed a great deal to the marine biology of Japan, and was quite epoch-making in the sense that such a large number of biologists participated in the difficult, and time-consuming, co-operative achievement. The fauna and flora of Mutsu Bay have thus been elucidated. The Survey was possible under the auspices of the Saitô Gratitude Foundation in Sendai, as mentioned above, to which we wish to express our cordial thanks at this opportunity.

As the materials for the instruction and research work, various forms are abundant and have been employed: oysters (*Ostrea gigas*, *O. nippona*, formerly identified as *O. circumpecta*), scallops (*Pecten yessoensis*), holothurians (*Caudina*, etc.) sea urchins (many species), *Nereis*, ascidians (*Cynthia*, etc.), etc. are representative.

Besides the routine, research work is continually being carried on by the staff of the Station round the year, and the members and students of the Biological Institute in Sendai also come, as often as possible, to work here. Outside investigators also will be welcomed as far as the facilities permit; applications should be made in advance.

The results of investigations carried out at MBS, especially by Drs. Kokubo, Nomura and Yamamoto, have furnished scientific foundation to the fisheries of Mutsu Bay, especially to the multiplication of the scallop, *Pecten yessoensis*, which is one of the most important marine products in Aomori Prefecture, and been highly appreciated.

Oceanographical Observations. Oceanographical observations have been carried on as routine work and recorded for the three decades since the opening of the Station. They may be proved of much use as the case demands. Some data on the oceanographical conditions at Asamushi are given below:

1926

	Maximum	Minimum	Annual mean	Remarks
Air temp. °C.	23.4 (Aug.)	-0.62 (Jan.)	11.23	{ Aomori 9.3 Miyako 10.9 Niigata 12.6
Sea water temp. °C.	22.83 (Aug.)	5.18 (Feb.)	12.91	

Spec. Grav.	25.05 (Sept.)	21.71 (Apr.)	24.29	{ Kuroshio, 26.50 Oyashio 25.00 Okhotsk Sea 24.50
Salinity	33.78 (Sept.)	29.43 (Apr.)	32.79	
Chlorinity ‰	18.70 (Sept.)	16.29 (Apr.)	18.15	

1953

Air temp. °C.	30.5 (Zul.)	-6.4 (Feb.)	11.34
Sea water temp. °C.	24.9 (Aug.)	5.39 (Feb.)	13.06
Chlorinity ‰	18.76 (Mar.)	15.67 (May)	17.60

Publications. The results of investigations carried out at the Station and those executed by the staff elsewhere have been published as the contributions from MBS mainly in the Science Reports of the Tôhoku (Imperial) University, 4th Ser. (Biology) or other leading journals. After the War, the Tôhoku Imperial University changed its name to the Tôhoku University ("Imperial" omitted) by the order of the commandor-in-chief McArthur during the occupation of the Allied Forces, and the name of the Science Reports also was changed accordingly. The number of contributions from the Station exceeded two hundred, and the preparation of the list have been needed.

After the War, this journal "The Bulletin of the Marine Biological Station of Asamushi [Asamushi Rinkai-Jikkenjo Hôkoku, formerly "Kaiyo Seibutsu Jihô" (meaning Journal of Marine Biology)] also started on Jan. 1, 1946, as a mimeographic publication, containing the reports of studies by the staff, and was distributed originally among a small domestic circle. As the economical conditions of the MBS and the printing facilities rehabilitated to some extent, the Bulletin began to appear as an ordinary printed journal, and the text also was written in English, intended for wider distributions to leading laboratories and institutes of the world, from which we receive valuable publications in exchange for our own. We also send out bound reprints of our contributions, which appeared in other journals than ours. Further exchange of publications is eagerly desired.

It is our pleasure to conclude this article with the announcement that the increase of the number of contributions from the Station has necessitated the publication of their list with indices, which are appended at the end of this issue.

CONTRIBUTIONS TO THE PHYSIOLOGY OF
THE HEART OF OYSTER
VI. THE ACTION OF NICOTINE ON THE ISOLATED
HEART OF OYSTER¹⁾²⁾

By

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(With 3 Text-figures)

I. INTRODUCTION

The physiological action of nicotine on the heart has been studied by numerous investigators and the nicotine is known to act on ganglion cells, thus blocking the nerve impulse. On the heart in vertebrates, in small doses it leads to temporary stimulation followed by depression, and in large doses depression follows immediately. In the molluscan heart, the nicotine effect is much like the inhibition by acetylcholine as reported for *Anodonta*, *Anomia*, *Venus*, etc.

The present preliminary investigation attempts to examine the effect of nicotine on the isolated heart of the oyster quantitatively.

II. MATERIAL AND METHOD

The material employed in these experiments was *Ostrea circumpecta* PILSBRY. The heart was isolated from the body. The method of isolation of the heart has been already described (1927).

The isolated heart of oyster, which normally pulsates in sea water, was perfused with various concentrations of nicotine solution, diluted with sea water, and the effects were observed by the kymographic method. The standard solution used in these experiments was diluted 1 : 100 solution. All experiments were conducted at room temperature. The solution was kept at the same temperature.

1) Contributions from the Shimoda Marine Biological Station, No. 90.

2) Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

III. EXPERIMENTAL RESULTS

The heart of oyster which normally pulsates in sea water was perfused with various concentrations of nicotine, and certain effects were observed in certain concentrations. The results are summarized as follows:—

Perfused with the nicotine concentrations such as $\frac{1}{8} \times 10^{-5} \sim \frac{1}{4} \times 10^{-5}$, the heart showed no response at all, and pulsated normally almost indifferent to this chemical. But some individuals responded to these concentrations and heart pulsation gradually decreased (Text-fig. 1)



Fig. 1. Effect of diluted nicotine solution.

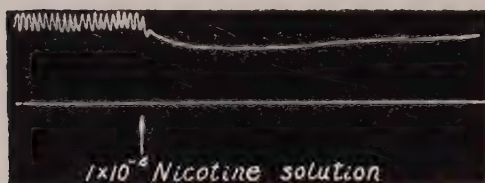


Fig. 2. Effect of nicotine. The heart immediately stopped in diastole.

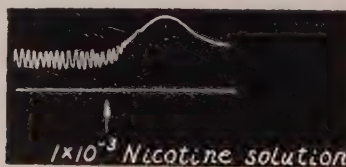


Fig. 3. Effect of nicotine. The heart increasing the tonus.

These phenomena are invariable in each individual. The threshold concentration of nicotine to the oyster heart could not be measured in detail, for the individual difference is so variable.

If more concentrated nicotine solutions such as 1×10^{-3} , 1×10^{-4} were used,

the heart immediately stopped the pulsation in diastole (Text-fig. 2).

Some individuals responded to the more concentrated nicotine solutions (1×10^{-3} , 1×10^{-2}), and the heart immediately increased its tonus and gradually stopped in systole (Text-fig. 3).

Nicotine seems to act upon the pacemaker mechanism as stated by DAVENPORT *et al.* (1940), since at low concentrations it slows the heart pulsation; it may affect the mechanism of contraction, since the amplitude is decreased. At higher concentrations, it stops the heart in diastole; that this stoppage is not due to the impairment of the mechanism of contraction is shown by the fact that the heart reacts to direct electrical stimulation with a strong contraction.

In all experiments, the effects of the nicotine were found to be somewhat permanent; tests with higher concentrations on a heart which had previously been treated with lower concentrations or *vice versa* did not bring about the same effect as treatment of a fresh heart, since the effects were never completely reversible.

DAVENPORT *et al.* (1940) reported, in recovery from nicotine in *Ariolimax*, that "the heart beats five times with large amplitude and then stopped in diastole for a short time. The stoppage was followed by several strong beats, and that process of periodic stoppage was followed in some cases by a series of beats of increasing number and continued until the heart had resumed a normal though amplified rhythm."

In the oyster heart such recovery process could not be observed and the pulsation only gradually recovered.

IV. GENERAL CONSIDERATION

These experiments on the effect of the nicotine on the heart of oyster show different results from those on the heart of Arthropoda.

CARLSON (1906) in his classic experiments on the heart of *Limulus* demonstrated that the nicotine in dilute solutions has a primary stimulating effect on the ganglion of an arthropod heart and that at higher concentrations the nicotine produces irregularity in rhythm, depression and paralysis. CARLSON showed that in lower concentrations nicotine has little effect on muscle itself. It seems, therefore, that in the crustacean heart perfused with nicotine, the intrinsic ganglion cells are stimulated.

DAVENPORT (1941) stated that on the effect of nicotine in the heart of *Astacus*, concentration 1:10,000 gave increase in amplitude and decrease in frequency; 1:5,000 a decrease in amplitude and irregularity of beat.

And also in *Cancer* heart, that 1:20,000 gave increase in amplitude and frequency; 1:10,000 increase in amplitude and frequency or increase in frequency

to systolic stoppage; 1:4,000~3,000 initial stimulation of frequency and amplitude followed by depression.

HAMILTON (1937) found in *Melanolus* that from 1:100 to 1:1,000,000 gave an increase in amplitude and slight decrease in frequency while low concentrations in some hearts gave initial increase in frequency.

YAEGER and GAHAM (1937), and YAEGER (1938) stated that the hearts of *Periplaneta* and *Prodenia* in low concentrations gave initial stimulation in frequency without depression; intermediate concentrations, stimulation followed by partial depression; and high concentrations, followed by depression and paralysis; concentrations giving initial stimulation increased the tone of heart.

In the molluscan heart, NAVEZ (1936) reported the action of nicotine on the heart in *Anomia* that perfused with 0.002 % nicotine the heart shows "Augmentation fréquence," with 0.005 % "Arrêt temporaire en diastole (1 à 5 min)" and with 0.01 % "Arrêt diastolique instantané."

DAVENPORT *et al.* (1940) stated with reference to the effect of nicotine in *Ariolimax* heart that positive inotropic and negative chronotropic effects were produced by nicotine in low concentrations. The first noticeable effect was a slowing of rhythm (1:7,000), a definite negative chronotropic effect could be observed (1:5,000) and diastolic stoppage with a few irregular beats of large magnitude (1:4,000). They considered that the nicotine acts upon the pacemaker mechanism, but it could not impair the mechanism of contraction. The grouped beats leading to the normal rhythm during recovery from nicotine treatment may be interpreted as the result of a gradual recovery of the mechanism of pacemaker.

In these experiments, the heart of oyster shows no excitation at all when perfused with any concentrations of nicotine. And the pulsation of the heart decreases the frequency and amplitude. But there are two cases showing the effects of nicotine on the heart of oyster. One is to increase the tonus which usually stops in diastole. The other is to increase the tonus suddenly which gradually stop in systole. The former is usually observable in low concentrations and the latter in higher concentrations.

The heart of the oyster is provided with accelerator and inhibitor nerves. Nerve cells are distributed in the cardiac muscle. Therefore, whether the effect of nicotine affects the ending of this inhibitor nerve and nerve cells with resulting decreases in amplitude, in frequency, and stopping in diastole or whether it affects the cardiac muscle itself and stops in systole is questionable.

In conclusion, nicotine is not the stimulating agent for the heart of oyster, and the latter usually stops in diastole by this chemical.

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THE BEHAVIOR OF CRUSTACEA EXPOSED TO COLORED LIGHT*

By

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(With 3 Text-figures)

INTRODUCTION

Because of the abundance of arthropods, especially insects, the ease with which they may be secured, and their adaptability to experimental work, they have been used in many investigations of light reactions. These investigations, made both in the field and in the laboratory, have included tests upon the reactions of these animals to lights of different colors. The different colors for the experiments were obtained by filtering white light through colored solution or glass, or otherwise from a prism spectrum.

The first recorded experiments upon the reactions of the arthropods to colored lights are those of PAUL BERT who published an account of his work on *Daphnia* in 1868. He discovered that *Daphnia* responded to each of the visible colors of the spectrum. When the entire spectrum was thrown on a trough containing these animals, the majority of them gathered together in the green and yellow, the most luminous region of the spectrum as judged by our eyes. MEREJKOWSKY ('81) experimented with spectral colors upon *Balanus* larvae and the marine copepod *Dias longiremus*. He recognized the importance of the intensity of the light and attempted to eliminate this factor by equalizing the luminosity of the respective colors as judged by his own eyes. Under these conditions he found the animals distributed equally in the different colors. He concluded that the lower crustaceans cannot see the different colors and are conscious of only one color in variations of intensity.

YERKES ('99) made a series of experiments upon the small crustacean *Simoecephalus vetulus* with spectral light. He reported in his account that this animal preferred the orange and yellow of a gas spectrum. VON HESS later ('20) made tests on a large number of different arthropods (*Daphnia*, *Polyphemus*, and

* Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

similar crustaceans). He used three kinds of glass to separate different regions of spectrum: one transmitted the long waves down to about $400\text{ m}\mu$, and others transmitted down as far as $313\text{ m}\mu$ and $280\text{ m}\mu$, respectively. BECHER ('23) found that *Daphnia* responds to light of wave lengths as short as $228\text{ m}\mu$. But it was later shown by MERKER ('30) that the response which the animals gave could be considered either as a positive or a negative response.

The present author ('50) has undertaken to discover the most effective pigment migration in the shrimp eye under the visible color spectrum and recognized that the most effective wave lengths are in the neighborhood of $510\text{ m}\mu$ and $455\text{ m}\mu$ respectively.

Although considerable attention has been paid to the reaction of crustaceans to colored light, comparatively little has been paid to the behavior of animals in colored light. In consequence, this paper intends mainly to show how some crustaceans behave when they are exposed to colored light.

Before going further, the writer desires to express his thanks to Prof. S. Nomura for his kind criticism.

MATERIAL AND METHOD

The materials used for this investigation were two species of fresh-water crustaceans: one is water flea, *Simocephalus vetulus* (O. F. MÜLLER), which had been cultured with hay infusion in the laboratory; the other is a shrimp, *Paratya compressa* (DE HAAN), on which my previous experiments of the pigment migration has been attempted.

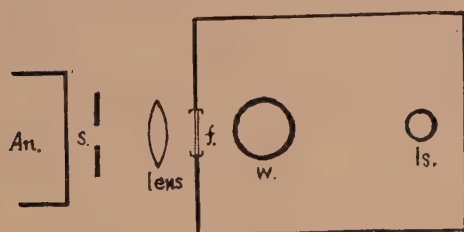


Fig. 1. Apparatus of the colored light test.

An. animal container

s. slit

f. filter

w. heat absorbing water bottle

ls. light source

The apparatus for furnishing colored light was shown in Fig. 1. The color filters employed here were four kinds of purple = V-P₁ ($400\sim 450\text{ m}\mu$), blue = V-B₁ ($467\sim 500\text{ m}\mu$), green = V-G₁ ($500\sim 550\text{ m}\mu$), and red = V-R₂ ($680\sim 700\text{ m}\mu$) respectively. For the light source was used a 500 watt kinematographic electric lamp with spiral tungsten filament. By using this lamp were obtained wave lengths from $415\text{ m}\mu$ to $700\text{ m}\mu$. The heat radiated from the light source was

absorbed by water layer. The intensity of light was measured by MATSUDA'S illuminometer which indicated directly the illuminating intensity in lux. By

changing the distance from the light source to the front surface of the animal container, the intensity of the colored light was regulated and the same intensity of 1000 lux for all chromatic light was obtained.

About 200 animals of *Simocephalus* were put into a glass vessel of 9.7 cm in diameter, which contained tap water up to 100 cc. But in the case of the shrimp experiment, 15 animals were put into a glass vessel (15.5×7.5×9.0 cm), containing 600 cc. of tap water.

For the purpose to test the effect of the monochromatized spectrum upon the animals, arrangements were made to project the bright spectrum on the scale by using ADAM-HILGER's wave length spectrometer (constant deviation type). In this case, however, the illuminating intensity upon the surface of the animal container was only 10 lux. Hence, this experiment by the monochromatized spectrum was not carried out.

The observation was done from October to November in the dark room of the laboratory, which was approximately at constant temperature ($17^{\circ}\pm 0.5^{\circ}\text{C}$).

OBSERVATIONS

I. The behavior of *Simocephalus vetulus* exposed to colored light.

The animals were tested with each of the four sets of different colors to determine whether they were responsive to the various wave lengths of light of an intensity used in these experiments. In each test, the animals were scattered uniformly in the glass vessel before exposure to light.

The animals illuminated with purple light, began to move simultaneously to the direction of slit beam of light and crowded together at the lighted wall side. The state has continued during the light exposure. When the animals were exposed to red light, they formed close order slowly, and then dispersed in the state as previous experiment. The specimens illuminated with blue light clustered fairly fast to the direction of slit beam of light, but few animals remained at the first state. When exposed to green light, they moved somewhat quickly to the wall of the light source, and swarmed there as long as lighted.

Fig. 2 shows diagrammatically the end states of animals in the container tested with purple, red, blue and green lights respectively.

II. The behavior of *Paratya compressa* to colored light.

The animals were tested also with each of the four sets of different colors to determine whether they were responsive to the various wave lengths of light of an intensity. The condition of animals before experiment was similar to that of the water flea, above-mentioned.

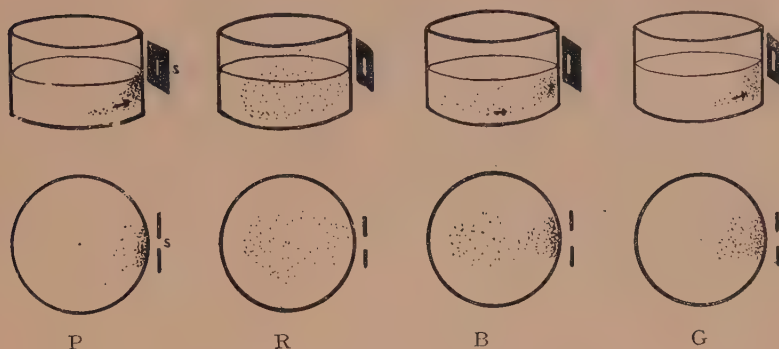


Fig. 2. The crowding or scattered states of *Simocephalus* exposed to purple, red, blue, and green respectively.

Upper: Side views Lower: Plan

S.... Slit P.... purple R.... red B.... blue G.... green

The animals illuminated with purple light, moved away simultaneously from the light on a course approximately parallel to the direction of the rays, and continued to swim at the distal end of the light source, as if to take refuge of light stimulation. When the animals were exposed to red light, they turned their body axis on a course parallel to the direction of the rays, but in a short time, they rested at the bottom of the container. The specimens illuminated with blue light clustered fairly fast to the distal position of the slit beam of light and continued to crawl in horizontal posture.

Then, exposed to green light, they moved somewhat quickly away from the light on a course approximately parallel to the direction of the rays, and continued to swim at the distal end of the light beam. In this case, some animals kept on crawling in vertical posture, some were in horizontal posture.

Fig. 3 shows diagrammatically the end states of the shrimps in the container tested with purple, red, blue, and green lights, similarly to the case of *Simocephalus*.

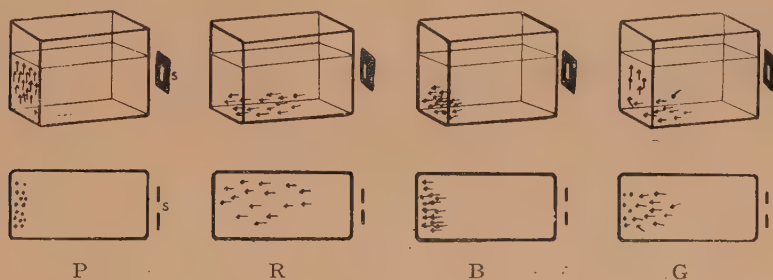


Fig. 3. The crowding or scattered states of *Paratya* exposed to purple, red, blue, and green respectively. The figure and notation are the same as in Fig. 1.

◇..... vertical posture ←..... horizontal posture

DISCUSSION AND CONCLUSION

The results obtained show clearly that the behavior of the crustaceans is dependent upon the wave length of light, certain colors are much more efficient as stimulating agents than others. That is to say, the most effective color light in controlling the behavior of the animal as a whole, is purple in both cases of *Simocephalus* and *Paratya*, and the red one was the least effective. Green was more effective than blue in *Simocephalus*, and *vice versa* in *Paratya*. The white light, on which nothing was described in the article of observations, showed the more striking effect on the animal behavior.

It may be interesting to compare briefly the writer's present work with his previous work on the relative efficiency of light at different wave lengths for the pigment migration of the shrimp eyes and to see where the results of the present investigation fit into the picture. It was recognized that purple and green were most effective to the distal pigment migration in the eye of the shrimp. The white light produced the considerable effect on the eye pigment migration. The red light had the weakest effect.

To the difference of reactions of the two kinds of animals attention should be paid. It may be caused by the differences of the responsiveness of animals to the light intensity.

If it is assumed that the reactions of the crustaceans are brought about by physiological changes produced by light on the photo-receptors of organism, it is conceivable that there exist some differences in the behavior of organism as a whole, depending upon the differential effects of the wave lengths of light.

SUMMARY

1. The behavior of organism as a whole exposed to colored light was observed on a water flea, *Simocephalus vetulus* and a freshwater shrimp, *Paratya compressa*.
2. The purple light (400~450 m μ) was the most effective stimulant to the animal behavior. The red light (680~700 m μ) was the least effective one.
3. It was conceivable that there exist some differences in the animal behavior, depending on the kinds of color light of the same intensity.

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METABOLIC PATTERNS IN BIVALVES
VI. A PRELIMINARY SURVEY INTO THE DISTRIBUTION
OF THE ACTIVITY TO DEAMINATE UREA IN THE SOFT
PARTS OF MARINE BIVALVES, *ANADARA INFLATA*,
MACTRA SULCATARIA AND *VENERUPIS*
*PHILIPPINARUM**

By

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(With 4 figures)

That the activity to deaminate urea is distributed in various parts of the clam, *Meretrix*, has been reported by the present author (1954 b). He has also reported that two species in the genus *Corbicula* differ in their activity to deaminate urea, as he studied them with total soft bodies (Ishida 1954 d). In carrying out these investigations the review by Florkin (1945), in which the presence of urease in lamellibranch tissues is given certain significance in respect of the nitrogen metabolism, has been referred to.

On the other hand, the author has been interested in the fact that certain activities are localized predominantly in certain organs or parts of bivalves. Urea deamination takes place with higher activities in the gill and mid-gut gland (Ishida 1954 b), and the breakdown of guanine seems to be localized almost exclusively in the gills (Ishida 1954 a), according to his own investigations on *Meretrix*. The lamellibranch gills are reported also by other workers to be the richest in content of carbonic anhydrase in many species (Freeman and Wilbur, 1948; Kawai 1954).

Taking account of these facts the author has carried out a survey into the distribution of the urea-deaminating activity in three pelecypod species, and has observed that they differ somewhat from each other in their patterns or types of distribution of the activity. These patterns—the distribution patterns—will be described and compared with each other in the following.

The author's gratefulness to Prof. Shichiroku Nomura, for his encouragement

* Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

and criticism, should be expressed cordially on this occasion.

MATERIAL AND METHOD

Fresh specimens of *Mactra sulcataria* Reeve, *Anadara* (*Scapharca*) *inflata* (Reeve), and *Venerupis* (*Amygdala*) *philippinarum* (Adams et Reeve), all being the inhabitants of sea-water, were used as materials. Their gills, mid-gut glands, mantles and feet were compared as regards the activity of urea-deamination. Specimens of adequate sizes were chosen so as the tissues of each organ could be collected from a single individual in an amount sufficient to be analyzed.

Each organ, weighing 0.3 g or more, was ground in a mortar and was diluted with neutral phosphate buffer to the volume ten or more times that of the organ itself. After standing for several minutes the tissue suspension thus prepared was centrifuged. The supernatant was used for the determination.

The activity of urea-deamination was determined by adding 0.8 cc of the above extract to 0.2 cc of 0.1 % urea solution in a Conway unit and comparing, through Nesslerization and electric colorimetry, the amount of ammonia-nitrogen in γ produced by the extract of 100 gm wet tissues in 15 minutes at room temperature (28–30°C) with that produced in the control preparation, which contained water in place of urea solution but was similar to the experimental in other respects (Ishida 1954 b).

RESULTS

1. *Mactra sulcataria*. The mid-gut gland showed the highest activity to deaminate urea in two out of three individuals of *Mactra sulcataria* investigated. In the other individual the activity was considerable in the gill, exceeding that in the mid-gut gland. These results will be seen in Table 1. They are also expressed in tetragonal patterns, which represent the activities of the four organs (Fig. 1).

2. *Anadara inflata*. This species, as is shown in Table 2 and Fig. 2, has the highest activity in the gill among four organs investigated. Next comes the mid-gut gland but far behind. The general feature of the distribution pattern seems to be analogous to that in *Meretrix* in which, however, the difference between the gill and the mid-gut gland was not so remarkable as in the present species. This may be recognized by comparing respective tetragons in Figs. 2 and 4.

3. *Venerupis philippinarum*. So far as investigated, the distribution of the urea-demaining activity in *Venerupis* seems to be rather disorderly if compared with those in other species described above. Mantle and foot, which were far less active in other kinds of shellfish, appeared to be the highest in activity in some individuals in this species (Table 3). Thus the tetragons to express distribution patterns are quite variable in shape, as is shown in Fig. 3.

Table 1

Table 1 The activity to deaminate urea, in the gill, mid-gut gland, mantle and foot of the bivalve, *Macra sulcataria* Reeve, at pH 7.0, 28-30°C.

Organ	Individual	Ammonia-nitrogen produced by extract of 100 mg tissues in 15 minutes		Ammonia-nitrogen removed from urea by extract of 100 mg tissues in 15 minutes (γ)
		with urea (γ)	without urea (γ)	
Gill	A	22.5	9.4	16.1
	B	33.7	8.4	25.3
	C	24.8	7.4	17.4
Mid-gut gland	A	46.8	11.4	35.4
	B	35.9	11.6	24.3
	C	37.0	15.8	21.2
Mantle*	A	16.7	9.1	7.6
	B	13.6	7.8	5.8
	C	9.4	5.8	3.6
Foot	A	10.1	7.3	2.8
	B	9.9	7.0	2.9
	C	6.7	4.1	2.6

*with siphons.

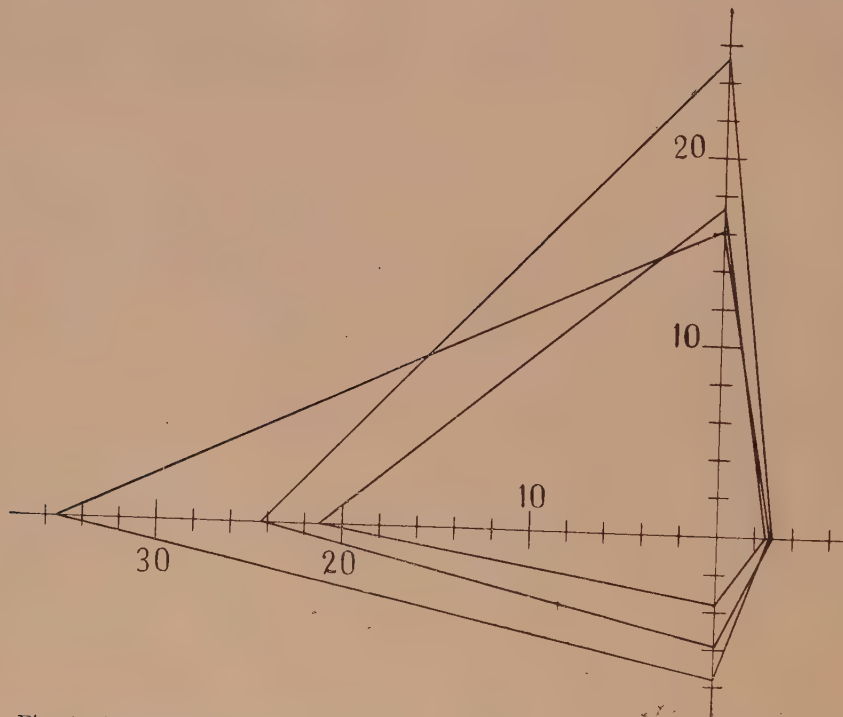


Fig. 1. Tetragonal representation of the distribution patterns of the activity to deaminate urea in *Macra sulcataria*. The activities will be read, in γ ammonia-nitrogen removed from urea by extract of 100 mg tissues in 15 minutes, upward for gill, to the left for mid-gut gland, downward for mantle, and to the right for foot.

Table 2

The activity to deaminate urea, in the gill, mid-gut gland, mantle and foot of the bivalve, *Anadara inflata*, at pH 7.0, 28-30°C.

Organ	Individual	Ammonia-nitrogen produced by extract of 100 mg tissues in 15 minutes		Ammonia-nitrogen removed from urea by extract of 100 mg tissues in 15 minutes (γ)
		with urea (γ)	without urea (γ)	
Gill	K	32.0	13.4	18.6
	L	22.4	6.4	16.0
	M	25.6	7.4	18.2
Mid-gut gland	K	16.4	10.8	5.6
	L	14.6	10.6	4.0
	M	15.6	10.4	5.2
Mantle*	K	9.9	6.7	3.1
	L	8.3	5.3	3.0
	M	7.8	4.4	3.4
Foot	K	9.4	6.7	2.7
	L	6.1	5.3	0.8
	M	8.8	4.7	4.1

* Marginal and caudal thicker parts.

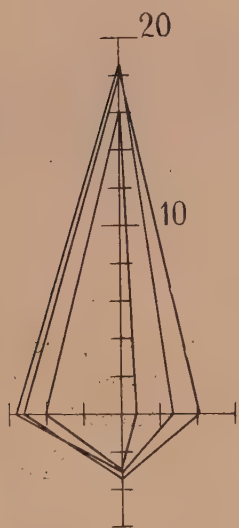


Fig. 2. Tetragonal representation of the distribution patterns of the activity to deaminate urea in *Anadara inflata*. The activities will be read as in Fig. 1.

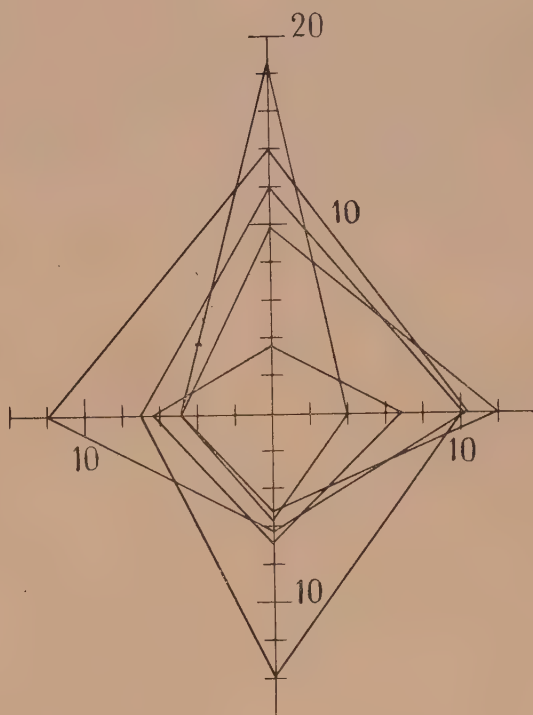


Fig. 3.

Fig. 3. Tetragonal representation of the distribution patterns of the activity to deaminate urea in *Venerupis philippinarum*. The activities will be read as in Fig. 1.

Table 3

The activity to deaminate urea, in the gill, mid-gut gland, mantle and foot of the bivalve, *Venerupis philippinarum*, at pH 7.0, 28-30°C.

Organ	Individual	Ammonia-nitrogen produced by extract of 100 mg tissues in 15 minutes		Ammonia-nitrogen removed from urea by extract of 100 mg tissues in 15 minutes (γ)
		with urea (γ)	without urea (γ)	
Gill	(x)	18.4	14.8	3.6
	(xx)	36.0	17.4	18.6
	R	27.6	15.6	12.0
	S	25.4	15.6	9.8
	T	35.4	21.4	14.0
Mid-gut gland	(x)	23.6	17.4	6.2
	(xx)	31.2	26.4	4.8
	R	29.4	22.4	7.0
	S	27.2	22.4	4.3
	T	41.4	29.4	12.0
Mantle*	(x)	12.8	5.9	6.9
	(xx)	12.2	6.6	5.6
	R	23.0	9.4	13.8
	S	15.6	10.4	5.2
	T	15.6	9.4	6.2
Foot	(x)	12.8	5.9	6.9
	(xx)	10.4	6.4	4.0
	R	22.4	12.2	10.2
	S	20.6	8.6	12.0
	T	19.0	8.6	10.4

* Without siphons.

(x) : Organs collected from 4 individuals.

(xx) : Organs collected from 2 individuals.

DISCUSSION AND CONCLUSION

It was noted, in above observations, that there are certain differences in the patterns of the distribution of the urea-deaminating activity with species and, to a certain extent, with individuals within a single species. Although the examples are not yet accumulated to the extent sufficient to give a definite conclusion, rough outlines of the characteristic patterns specific to respective species could be suggested. In the former investigation on the urea-deamination in *Meretrix* the author carried out determinations with materials from different individuals. The data thus obtained may also show at least the general outline of the pattern, which is expressed figuratively in Fig. 4 for the sake of comparison with other species, in case there is more or less a definite order of the activities among different organs. But in some species like *Venerupis* the pattern may vary considerably with individuals, and it is in such cases that the determinations with organs from a single individual must especially be necessary.

Generally speaking, the distribution pattern of the urea-deaminating activity could be classified into three types. The first type may be called "branchial",

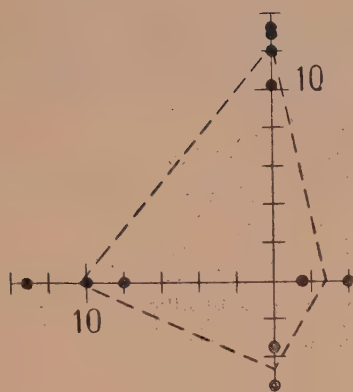


Fig. 4. Tetragonal representation of the distribution patterns of the activity to deaminate urea in *Meretrix meretrix lusoria* (Gmelin). The activities will be read as in Fig. 1. The data are taken from the author's former work (Ishida 1954 b), and are expressed on respective axes with dots which could not be connected with each other with solid lines, as they represent different individuals.

and may represent patterns of *Anadara* and *Meretrix*, where the activity is largely localized in the gill lamellae. The second or the intermediate type may be called "hepatobranchial" and may represent the pattern found in *Macra* where the activity is highest in the gill and or the mid-gut gland. The third type, which represents the pattern of *Venerupis*, could hardly be called a type, for it is characterized by its irregularity of the distribution of activity. But the author would call it "irregular" type to discriminate it from other types. As this irregularity was observed in specimens which had been treated in practically the same manner in the same place before the use for experiments, it could hardly be interpreted as due to environmental or manipulatory irregularities.

The classification of the types as such, however, must not be taken as rigorous, for it may be revised by further investigations and also by finding out certain other organs or parts which are more important than the present four organs in respect of the deamination of urea or other activities. So far, nevertheless, it may be of some use for comparing general outlines of nitrogen catabolism in relation to the anatomy of bivalves and, perhaps, of certain other groups of animals.

The physiologic significance of the molluscan gill lamellae has been emphasized in the works of several authors. This has been the case especially with the activity of deaminating guanine in *Meretrix* (Ishida 1954 a). Carbonic anhydrase is reported to be localized very largely, though by no means exclusively, in the molluscan gills (Freeman and Wilbur 1948; Ikinaga 1954; Kawai 1954). The author, however, will report elsewhere that the gill takes not the highest, but rather a very low position as regards the activity of removing hydrogen from hypoxanthine and xanthine (Ishida 1955). Thus he believes that the investigations in the comparative way as such may contribute to throwing some light on metabolic patterns of lower animals, and it is for this reason that he attempts to express figuratively the distribution of the urea-deaminating activity in the bivalves.

In short, the deamination of urea seems to go on most actively in the gill in

Meretrix and *Anadara*. In *Macra*, on the other hand, the mid-gut gland takes a higher position than the gill in this regard. The distribution of the activity in *Venerupis* seems to be more universal within its soft parts and more irregular and sporadic than in other species investigated.

Among all the materials hitherto studied by the author, the gill and the mid-gut gland of *Macra* have shown eminently high activities of deamination.

SUMMARY

1. Distribution of the activity of deaminating urea in gills, mid-gut glands, mantles and feet of three marine species of bivalves was investigated.

2. In *Macra sulcataria* the activity was highest in the mid-gut gland and then in the gill, whereas it was lowest in the mantle and foot.

3. The gill was the main site of urea-deamination in *Anadara inflata* in which other three organs were rather poor in this activity. This species resembles *Meretrix* in which the activity seemed to be distributed in the order: gill — mid-gut gland — mantle — foot.

4. In *Venerupis* the distribution appeared to be rather irregular and sporadic, the feet and mantles being more important sometimes.

5. Figurative representation and classification of distribution patterns were attempted.

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STUDIES ON THE PIT ORGANS OF FISHES
III THE DISTRIBUTION OF THE LARGE PIT ORGANS*

By

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(With 9 figures)

The large pit organs have been found in sharks, lung fishes, *Polypterus*, *Amia*, ganoids, and teleosts. These organs are commonly seen as white spots by the naked eye examination on account of the lack of pigmentation around them. They are arranged on the head and trunk in definite lines, though their number dotted in each line exhibits considerable variations according to each individual, and moreover sometimes on the opposite side of the same specimen. However, each species has respectively the definite pattern of the distribution of these organs.

Merkel ('80) already pointed out that the presence of the pit organs was correlated with the occurrence of the other sense organs of lateral line system, *i.e.*, they were most numerous in those teleostean fishes where the canal organs were reduced in number. Accordingly, it would be expected that the fish with prominent pit organs is provided with poor canal lines, and reversely in the fish with well-developed canal system the development of pit organ is poor. From such a point of view as above-mentioned, the distributions of the large pit organs in the following nine kinds of fishes have been compared in connection with the degree of development of the canal line in this paper: the catfish, carp, *Carassius auratus*, *Leuciscus hakuensis*, rainbow trout and *Oncorhynchus keta*, all with well-developed canal line; the stickleback with faintly developed canal line; the loach with a few of canal organs on its trunk and none on its head; *Oryzias latipes* without canal organs at all.

Here, I wish to express my gratitude to Prof. Dr. S. Nomura of the Tōhoku University for his valuable criticism concerning the observations. Thanks are also due to Miss T. Nakamura for her trouble of collecting the materials.

* Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi

(mhl) runs to a laterocaudal direction in a slight curve, innervated by the r. supratemporalis glossopharyngei. The posterior head line (phl) runs irregularly, however, almost parallel with the middle head line. This line is innervated by the r. lateralis vagi. In the anterior head line of a 250 mm specimen, there are three sense organs on each side, in middle five, and in the posterior four. On the cheek, there is one line (cl) which extends obliquely to the mandible across the cheek. This line is innervated by the r. hyoideus and r. mandibularis externus VII. In the case of a 250 mm specimen, it consists of eight sense organs on each side. As Atoda already mentioned, this line happens occasionally to be separable into three lines. In such a case, a horizontal line and a vertical can be distinguished as in other teleosts. Posterior to the mouth there is another line of pit organs (orl) which seems to be homologous to the oral line in the cyprinids and cobitids (Lekander '49). This line receives its nerve from the cutaneous branch of the r. mandibularis externus VII and consists of four sense organs in the above-mentioned specimen. On the snout, there are two lines, one lies at the base of the anterior nasal aperture, and the other near the median line of the upper jaw. The former (nal) should be named the nasal line from its position and receives its nerve from the r. buccalis. The latter (rcl), which is represented by a single pit organ in a 250 mm specimen, is innervated by the r. ophthalmicus superficialis and may be named the rostral commissure from its situation.

According to Allis ('04), five lines of pit organs are found on each side of the head of *Silurus*: a short rostral commissure, an anterior head pit line and a middle one, and two cheek lines. Further, in *Ameiurus* (Herrick '01) the following five lines are distinguishable: a rostral commissure, an anterior, middle, and possibly a posterior, head pit line and a line along the preopercular. Thus, the pit lines of the Japanese catfish are a little more developed in comparison with that of *Silurus* and *Ameiurus*.

On the dorso-lateral side of the body, there are many transverse rows of pit organs (tbl) (Fig. 2). The number of these lines is not less than ten. The sense organs of each line decrease in number as the line is situated posteriorly, viz., an anterior line consists of five or six sense organs, while a posterior lines consist of two or three organs. Another one (hbl) runs horizontally on the ventro-lateral side almost parallel with the main lateral canal line. This line consists of about eleven sense organs in a 250 mm specimen. These lines receive their nerves from the r. lateralis vagi.

(2) The loach, *Misgurnus anguillicaudatus*. About the distribution of large pit organs in the cobitoid fish, there have been investigations by Miyadi ('29) and by Lekander ('49). I also made a brief report in 1950 on the loach, and the following is the result of further observations since then.

The development of canal system, as Miyadi already pointed out, is very

poor in the loach, on whose head it is not seen at all, but only the pit organs (Fig. 3, a, b). The appearance of the pit organs is nearly similar to that of the catfish.

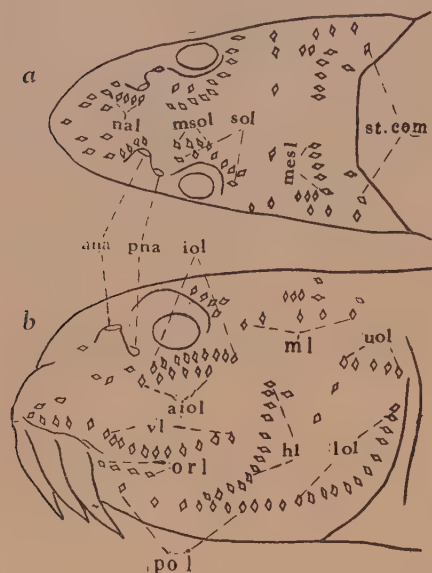


Fig. 3. Schema showing the distribution of the large pit organs on the head of the loach, 204 mm. a, dorsal view; b, side view. aiol, accessory infra-orbital line; hl, horizontal line; iol, infra-orbital line; lol, lower opercular line; mesl, medial extrascapular line; ml, main lateral line; msol, medial supra-orbital line; pol, preopercular line; sol, supra-orbital line; st. com, supra-temporal commissure; uol, upper opercular line; vl, vertical line. For other reference letters see Fig. 2.

line (nal) innervated by the same nerve as in the above-mentioned two. The organs scattered on the snout seem to correspond to the rostral pit-commissure of other teleosts. Along ventral side of the eyes, there runs the infra-orbital line (iol), which is accompanied by an accessory infra-orbital line (aiol). These two lines are innervated by the r. buccalis. On the cheek are four lines, a horizontal (hl), a vertical (vl), a preopercular (pol), and an oral line (orl), all of which are supplied by branches from the truncus hyomandibularis. Posterior to the orbit is another line of pit organs (ml). It runs straightly caudad from behind the orbit, and consists of five organs on each side in a 204 mm specimen. These organs are supplied from the r. oticus and lateralis vagi. Thus, this line should correspond to the main line of the other fish. On the operculum, an upper (uol), and a lower,

However, the distribution on the head is by far denser than in the catfish and resembles a state in *Nemachilus barbatula* and *Cobitis teania* (Lekander '49). On the top of the head, the pit organs are scattered, and not arranged in particular groups which may be designated as anterior, middle and posterior lines as in the catfish. Only the medial extrascapular line (mesl) is clear, and this line is innervated by a branch of the r. lateralis vagi. A line (st. com) runs almost parallel to the medial extrascapular line and contains on each side, in the case of a 204 mm specimen, two organs, which are innervated by the same nerve as in the above-mentioned line. This line may be called the supra-temporal commissure. Between the eyes there are two lines, a supra-orbital line (sol) and a medial supra-orbital line (msol), which are supplied from the r. ophthalmicus superficialis VII. On the base of the anterior nasal aperture there is a nasal

opercular line (lol) are distinct. These two lines are innervated by the r. opercularis superficialis.

The distribution of the pit organs on the trunk is not visible so clearly as those on the head, and the number of the organs is considerably large. On each side of the trunk, two main lines (a middle and a dorsal body line) and one branch line of pit organs run. Concerning the arrangement of the organs on the trunk, my observations coincide with the results of Miyadi's ('29), so I will dispense with the note concerning it.

(3) *Oryzias latipes*. As there was a brief report on the distribution of pit organs of this fish by Yamamoto ('47), I made a close observation and tried a comparison with the above-mentioned two kinds of fish. As I mentioned before,

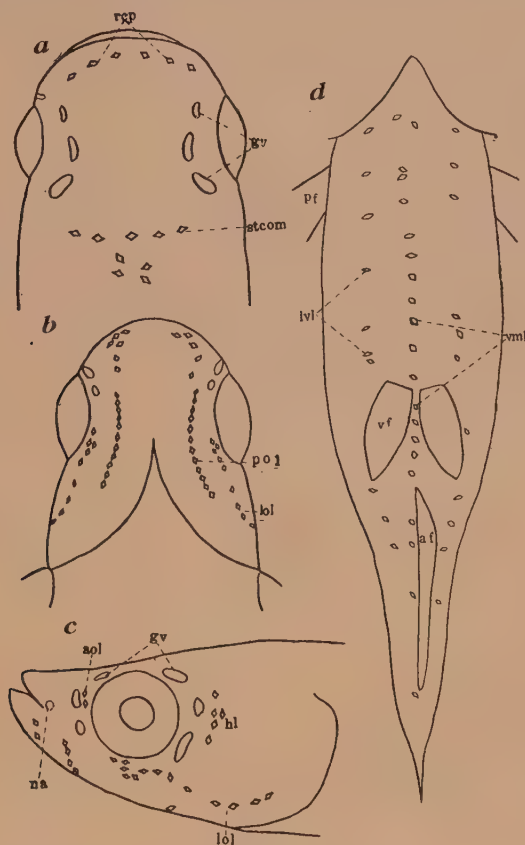


Fig. 4. Schema showing the distribution of the large pit organs on the head and trunk of *Oryzias latipes*, 32 mm. a, b, and c are dorsal, ventral and side view of head, respectively; d, ventral view of trunk. af, anal fin; aol, antorbital line; gv, groove organs; lvi, latero-ventral body line; na, nasal aperture; pf, pectoral fin; vml, ventro-medial body line. For other reference letters see Figs. 2 and 3.

this fish has no canal system at all (Fig. 4, a. b. c). I have not yet traced the nerve endings, so the naming of pit organ line has been conventionally made according to its respective position.

The shape of pit organs in this fish is not lozenge, but a little irregular ellipse. Most of the organs exist separately, but sometimes two or three gather in one group. The most remarkable difference from the catfish and the loach, is that *Oryzias latipes* has two or three grooves (gv) on the anterior, dorsal and posterior sides of the orbit respectively. In each groove a large pit organ is situated, the histological structure of which was described in my previous paper (Satō, in press). Viewed from the surface, the groove has two or three hollows in its middle part. Yamamoto has called it the "groove organ," and I agree with him. These groove organs seem to correspond to the organs of the supra- and infra-orbital line of other fishes. Immediately in front of the orbit, there are a few of pit organs (aol) which are taken for the antorbital line. In the snout, there is a line (rcp) which is thought to correspond to the rostral commissure in other fishes. In this fish, the nasal pit line does not exist. On the postdorsal side of the postorbital groove organ, a few of pit organs are irregularly arranged. This line (hl) is thought to correspond to the horizontal line in the loach and other fishes. A line (lol) runs along the lower margin of the operculum and seems to be a lower opercular line. On the cheek, there are some pit organs. On the ventral margin of the cheek, about ten pit organs are arranged in comparatively regular bow line. This line (pol) corresponds to the preopercular line in other fishes. In front of this line a few organs are irregularly grouped, which might be the anterior mandibular line. At the top of the head there is a transverse line (st. com) which includes several organs and may be called the supra-temporal commissure.

On the trunk there are four lines: a dorso-median, a dorso-lateral, a latero-ventral and a ventro-median line, each of which runs from the anterior to the posterior. The dorso-median line starts from behind the above-mentioned supra-temporal commissure and terminates immediately in front of the dorsal fin. In the line under consideration, about six pit organs are arranged with considerable intervals between each other. The dorso-lateral line runs from the posterior margin of the operculum in parallel with the above-mentioned dorso-median line and reaches the dorsal fin. In this line, a few pit organs are arranged. The latero-ventral line (Fig. 4, d: lvi) is stretched from the ventral margin of the operculum to the base of the caudal fin, along which ten more pit organs are arranged. The ventro-median line (vml) starts from the throat and, running on the ventral centre, ends at the base of the caudal fin, and comprises about twenty organs. This line is the most well-developed one among the lines on the trunk, but is seen neither in the catfish nor in the loach.

(4) *Cyprinus carpio*, *Carassius auratus* and *Leuciscus hakuensis*. These three

kinds of fish belong to the cyprinid. The lateral line system of the cyprinoid fishes was investigated by Lekander ('49). However, in Japan there has never been any investigation of the pit line in these fishes. Our three kinds of fish above-mentioned are all equipped with well-developed canal line.

The carp, *Cyprinus carpio*. On the head of this fish a number of pit organs are distributed (Fig. 5, a, b). A surface view of these organs is not a lozenge in

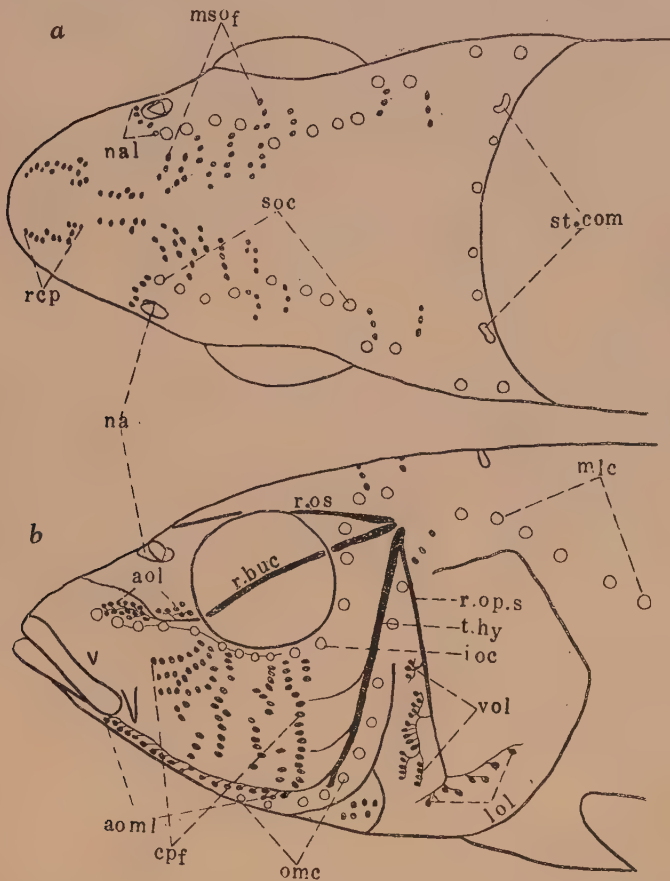


Fig. 5. Schema showing the distribution of the large pit organs (black dots) on the head of the carp, 43 mm. a, dorsal view; b, side view. aoml, accessory operculo-mandibular line; cpf, cheek pit field; ioc, infra-orbital canal; ms of, medial supra-orbital field; r. op. s, r. opercularis superficialis; omc, operculomandibular canal; soc, supra-orbital canal; vol, vertical opercular line. circles, pores of canal line. For other reference letters see Figs. 2, 3, and 4.

form, but an ellipse, and the size is smaller than that of the catfish and the loach. In the anterior part of the snout, there is a rostral commissure line (rcp), and this line runs toward the caudal direction in a slight curve, and consists of no less than

twelve organs on each side in a 43 mm specimen. A little behind this line, several organs are arranged in a straight row. These are innervated by a branch from the supra-orbital trunk. Though it is not yet clear which line in other fishes corresponds to this line, it seems to be a part of the median supraorbital line. Several pit lines are found between the supra-orbital canals of both sides. Each line is short and cannot be distinguished from one another as a marked line respectively. So it will be more proper to call them a medial supraorbital field (msof) as a whole without making a distinction. All the sense organs constituting this field are innervated by branches from the supra-orbital trunk. At the base of the nasal aperture, there is a nasal line (nal) which consists of six organs on each side, in the same specimen above-mentioned. On the top of the head there is no distinct pit line. Only two short lines are recognized in the posterior part of the region where the supra- and infra-orbital canals are continuous with each other. I could not ascertain the innervation to these two lines. In front of the orbit, ten more pit organs are arranged along the infraorbital canal. These organs are all innervated by the r. buccalis, and this line (aol) is unquestionably an antorbital line. In the cheek a lot of pit organs exist, but as they are difficult to divide into distinct lines it is probably better to designate them as a cheek pit field (cpf). The organs in this field seem to be innervated by branches from the infra-orbital and hyomandibular trunks. At the ventral part of the cheek ten more pit organs are arranged along the operculomandibular canal and these clearly form an accessory operculo-mandibular line (aoml) which receives a branch from the hyomandibular trunk. On the operculum there are two lines, one of which is a vertical opercular line (vol) and more than twenty organs are arranged irregularly along the anterior margin of the operculum. The other is a lower opercular line (lol) and several organs are arranged almost straight along the ventral margin of the operculum. Occasionally there happen such cases in which some organs are scattered in the inter-opercular region.

As mentioned above, the pit line system on the head of the carp is so prominent that it stands comparison with that of *Leuciscus rutilus*, *Phoxinus phoxinus*, *Abramis blicca* and *Tinca tinca* (Lekander '49). However, on the trunk, as far as I have examined, no marked pit lines were recognized.

Carassius auratus. Pit line system of this fish is not prominent. Only a few pit lines are recognized on the snout, parietal region and cheek (Fig. 6, a. b). On the snout there are two lines, a rostral commissure (rcp) and a medial supra-orbital line (msol). These two lines consist of several organs and are short. On the parietal region there is a short line. Along the supra-temporal commissure (st. com) a few of the pit organs are dotted. A line (vl) on the cheek is comparatively long and consists of more than ten organs. I have not yet examined the innervation to these organs, so I cannot give a definite name to this line. But, from

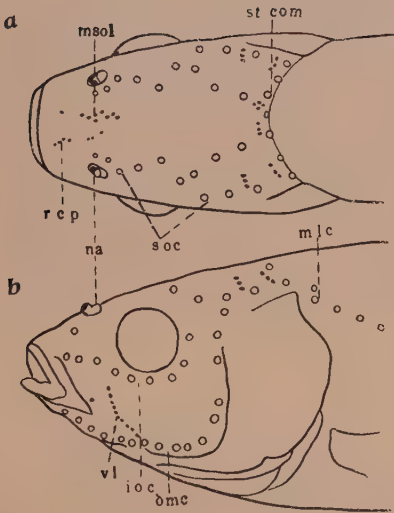


Fig. 6.

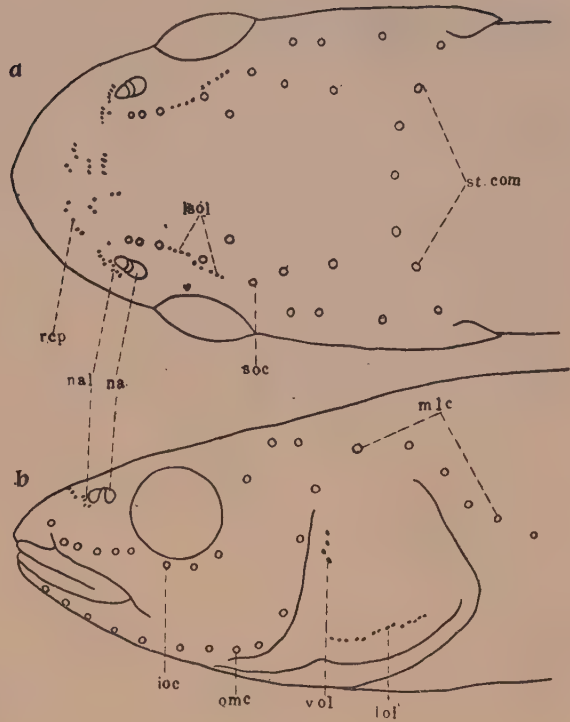


Fig. 7.

Fig. 6. Schema showing the distribution of the large pit organs (black dots) on the head of *Carassius auratus*, 41 mm. a, dorsal view; b, side view. For reference letters see Figs. 2, 3, 4, 5. circles, pores of canal line.

Fig. 7. Schema showing the distribution of the large pit organs (black dots) on the head of *Leuciscus hakuensis*, 124 mm. a, dorsal view; b, side view. lsol, lateral supra-orbital line. For other reference letters see Figs. 2, 3, 4, 5. circles, pores of canal line.

its situation it may correspond to the vertical line of other teleosts. On the trunk I could not find any remarkable pit line.

Leuciscus hakuensis. According to Lekander ('49), the pit line system in *Leuciscus rutilus* is so prominent that there are recognized more than ten pit lines and a pit field. However, those of *Leuciscus hakuensis* are extremely few and faintly developed (Fig. 7, a. b). Only on the snout and operculum there are a few pit lines seen. In the anterior part of the snout a rostral commissure (rcp) exists and consists of three or four organs on each side, in a 124 mm specimen. Nearly parallel with this line several pit organs are arranged. I think that all of these organs should be taken as the medial supra-orbital line. But, the innervation is not clear, so I cannot give a particular name to these organs. At the base of the nasal aperture there is a nasal line (nal) and on the lateral side of the supra-orbital canal a lateral supra-orbital line (lsol). The lateral supra-orbital line is com-

paratively long and consists of about ten organs on each side, in the above-mentioned specimen. On the operculum, there are two pit lines, a vertical (vol), and a lower, opercular line (lol). The former is short, but the latter a little longer. On the trunk there is no prominent line.

The result of comparison of these three cyprinoid fishes is as follows: all these three fishes are equipped with the well-developed canal system, but of the developmental degree of the pit line system on the head there is considerable difference between one another. The carp is favoured with very prominent pit line system, on the other hand *Carassius auratus* and *Leuciscus hakuensis* have only faintly developed ones. According to Lekander ('49), the cyprinoid fishes are generally equipped with comparatively prominent pit line. However, according to my results it is not necessarily so.

(5) The stickleback, *Pygosteus sinensis*. The canal line system of *Pungitius kaibarae*, a kind of stickleback, was investigated by Miyadi ('29), but about *Pygosteus sinensis* there have been no observation up to the present. The development of canal line system of this fish is not remarkable (Fig. 8, a. b). The

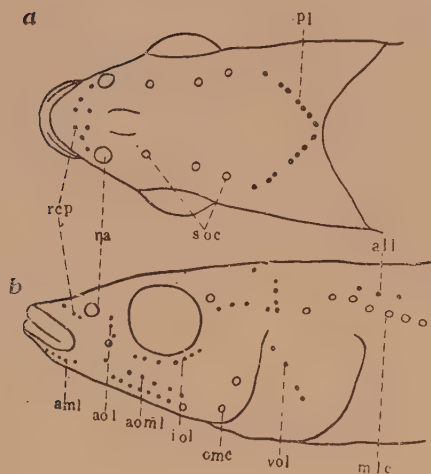


Fig. 8.

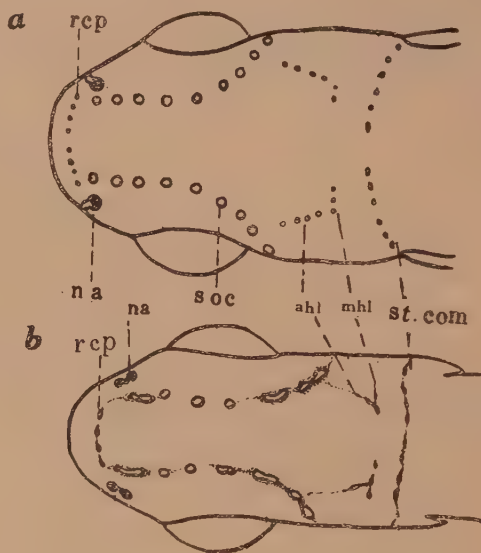


Fig. 9.

Fig. 8. Schema showing the distribution of the large pit organs (black dots) on the head of the stickleback, 40 mm. a, dorsal view; b, side view. all, accessory lateral line; aml, anterior mandibular line; pl, parietal line. For other reference letters see Figs. 2, 3, 4, 5. circles, pores of canal line.

Fig. 9. Schema showing the distribution of the large pit organs (black dots) on the head of the rainbow trout (a), 28 mm, and *Oncorhynchus keta* (b), 34 mm. dorsal views. For reference letters see Figs. 2, 3, 4, 5. circles, pores of canal line.

infra-orbital canal, operculo-mandibular canal and a part of the canal line lying in the temporal region do not form a perfect canal. Namely, some of the organs constituting these canal lines are not closed in the canal, but exist at the bottom of shallow groove. In this fish, the pit organs are arranged on the head and trunk. On the snout a rostral commissure (rcp) exists, but a nasal line cannot be seen. In front of the orbit there is a short line, an antorbital line (aol). On the cheek an accessory operculo-mandibular line (aoml) runs along the operculo-mandibular canal, and in front of this canal there is an anterior mandibular line (aml). A "V" shaped distinct line (pl) is found on the top of the head. This line consists of seven organs on each side, in a 40 mm specimen, all these organs being situated at bottom of wide depression. I have not yet examined the innervation to this line, so I named conventionally this line a parietal line. On the operculum there is a short vertical opercular line (vol). A few organs are arranged along the anterior part of the main canal of the trunk. This line (all) should be named an accessory lateral line.

(6) *Salmo irideus* and *Oncorhynchus keta*. About the pit line system of these two kinds of fish there has been no report at all. The following results are obtained in the young fishes of these two species mentioned, of the body length below 40 mm. But it is supposed that there is little difference between the young and the adult, as far as the distribution of the pit organs is concerned. Though the canal line is well developed both on the head and trunk, the pit line is recognized only on the snout and top of the head (Fig. 9, a. b). On the snout a rostral commissure (rcp) lies forming a line, and on the top of head there are seen an anterior (ahl) and a middle head line (mhl), which are short and consist of three or four organs on each side. In the posterior margin of the head, there is one considerably long line (st. com), which is a supra-temporal commissure and connects the main canal line on each side.

The development of the pit line system on the head of the rainbow trout and *Oncorhynchus keta* is extremely poor, and no pit line could be found on the trunk.

SUMMARY

1. The distribution of the large pit organs in the nine kinds of fish was considered in connection with the developmental degree of the canal line system.

2. The catfish, the carp, *Carassius auratus*, *Leuciscus hakuensis*, the rainbow trout, and *Oncorhynchus keta* have a well-developed canal line system, but the stickleback is provided with an imperfect canal line, and the loach has a poorly developed canal line in the process of reduction on the trunk and none on the head, and *Oryzias latipes* has none at all.

3. On each side of the head of the catfish, there are seven lines of the large pit organs, and of these only the line at the cheek is comparatively long, but the

other six lines are short.

4. On the head of the loach are found more than fourteen pit lines, and the number of organs in each line are by far larger than in the catfish.

5. On the head of *Oryzias latipes*, distinct several lines are found. On the anterior, the dorsal and the posterior side of the orbit, there are the "groove organs," which give the most remarkable characteristic to the pit line system of this fish.

6. On the head of *Carassius auratus*, *Leuciscus hakuensis*, the rainbow trout, and *Oncorhynchus keta*, comparatively small number of the large pit organs are found. On the other hand, the stickleback has a considerable number of the organs on its head.

7. As above-mentioned, the large pit organs on the head generally more develop in the fishes, which have imperfect canal lines or none, than in the fishes with the well-developed canal line. But, the carp has both the well-developed canal line and a lot of the large pit organs on the head. Accordingly it seems that there is not always close relation between the abundance of the large pit organs on the head and the existence or development of the canal line.

8. The fishes with a number of large pit organs on the trunk are very few. Of the nine forms above-mentioned, the fishes with a number of large pit organs on the trunk are the catfish, the loach, and *Oryzias latipes*. Generally speaking, both the fishes with a faintly developed canal line and those without, have the prominent pit line system on their trunk.

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ON REARING OF THE SCALLOP SPATS IN
TANK AND POOL¹⁾²⁾

By

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(With 1 figure)

I. INTRODUCTION

Spawning of the scallop, *Pecten yessoensis* Jay, in Mutsu Bay seems to depend upon a rise of sea water temperature during the breeding season. About 40 days after spawning, in early June, scallop larvae grew to full grown swimming prodissoconch with about 300 micra of shell length and were attached by their byssus to collectors, set nets or bottom sea weeds. In general, the number of attached spats runs parallel with the intensity of the spawning (Yamamoto 1952). These attached spats, which reached 6-10 mm in shell length, turn to bottom life from late July to early August.

Meanwhile, a high mortality of these spats was ascertained, amounting in many cases from 99 per cent to 100 per cent according to habitats (Yamamoto and Eto, in preparation). The high mortality has not been explained, but such phenomenon often was observed during summer and early autumn. The mortality decreased in November when the spats attained from 30 to 40 mm in shell length. The high mortality as in scallop spats has recently been reported in certain developmental stages of some lamellibranchs in our country; the ark *Anadara subcrenata*, the surf clam, *Macra sachalinensis* and the clam, *Venerupis japonica* (Hiroshima Fish. St. 1952, Okayama Pref. Fish. Sect. and Fish. Exp. St. 1952, Hokkaidô Fish. Exp. St. 1953, 1954, Aichi Fish. Exp. St. 1952, 1953, Itô and Kokiso 1954).

The writer has been investigating a means for controlling the high mortality of the young scallop mentioned above. First, based upon the fact that the mortality of the spat differs according to habitats, the inhabitant species of the habitats, where the mortality of the spat is comparatively low, were distinguished.

¹⁾ Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

²⁾ Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 212.

By employing the biotic indicator, the area where the spat may survive favorably was discriminated in Mutsu Bay. Detailed results will be published at another opportunity.

Second, the scallop spats were reared in tanks or small pools filled with normal sea water. The spat showed a high survivorship during about four months in the tanks and grew to 30 mm or more in shell length by late November. Herein will be given preliminary descriptions concerning the processes of rearing of the spat in tanks and a small pool, based upon the experiments made during these three years, especially in the season of 1954.

The writer expresses his cordial thanks to Professor Shichiroku Nomura and Mr. Shûichi Kodera, for their valuable advices and criticisms, and to Professors Isao Motomura, Eishirô Sawano and Mutsuo Katô, for their kind advices. The author is also indebted to Messrs. Bunryû Tsubata, Sashichi Satô and Juji Hasegawa, for their kind assistance during the work. The writer extends his acknowledgement to the Aomori Prefectural Government and the Foundation in Support of the Marine Biological Station, Tôhoku University, for the grants awarded to the writer.

II. REARING OF SPATS IN TANKS AT ÔMINATO

About 10,000 or more spats, which had attached themselves to collectors, were collected and placed in three concrete tanks. The aquaria used in the experiments were set outside of the Fisheries Laboratory at Ôminato, Aomori Prefecture, and each measured $1.8 \times 2.7 \times 1.5$ meters in size and contained about 6 cubic meters of normal sea water. Each aquarium was fed with pumped up and unfiltered sea water at the rate of a ton per 3 to 4 hours, namely from 6 to 8 tons per day.

The problem of rearing the spat in the aquarium was focused on finding appropriate food. Kinoshita and Hirano attempted to determine the food of the scallop by examining its stomach contents. Often only a few diatoms and protozoans could be recognized (1935), as in the case of the oyster. Recently, detailed investigation revealed that living phytoplanktons are of no importance as food to the oysters and related animals (Petersen 1911, Moore 1913, Blegbad 1914, Coe and Fox 1944, Korringa 1949).

In the present investigation, as food the following two were used: collected plankton mainly composed of phytoplankton such as *Chaetoceros*, *Rhizosolenia* etc., or cultured diatoms (*Nitzschia* and *Skeletonema*) amounting to 450–500 cc of the precipitated volume, and 500 g per day of a deep green juice pressed out from clover. Sawano has histochemically found that the juice of clover may be a favorite food for the scallop and that the chloroplasts in the juice pressed out from clover were digested by phagocytes in the digestive diverticula of the spat (1953).

As feeding every evening, the sea water supply to the tanks was stopped, thus the volume decreased to about a quarter and in the morning the water works were opened again.

In the control, the water flow was open continuously without any feeding, but the unfiltered water contained 200 cc or more of destroyed plankton and detritus per ton of sea water. In the experiment of the previous year, the water was filtered through calico bags in the control, and the spats died in succession during a week or so. Therefore even in the control the sea water was used without filtration.

The culturing in the tanks was continued for about four months from early August to late November, the mortality of the scallop during these months was 15.5 per cent, 7.1 per cent and 35.8 per cent in plankton feeding, juice of clover feeding and control respectively. The most luxuriant growth was observed in the plankton feeding spat in comparison with the other two cases and this seems to be comparable with the one under natural conditions (Fig. 1).

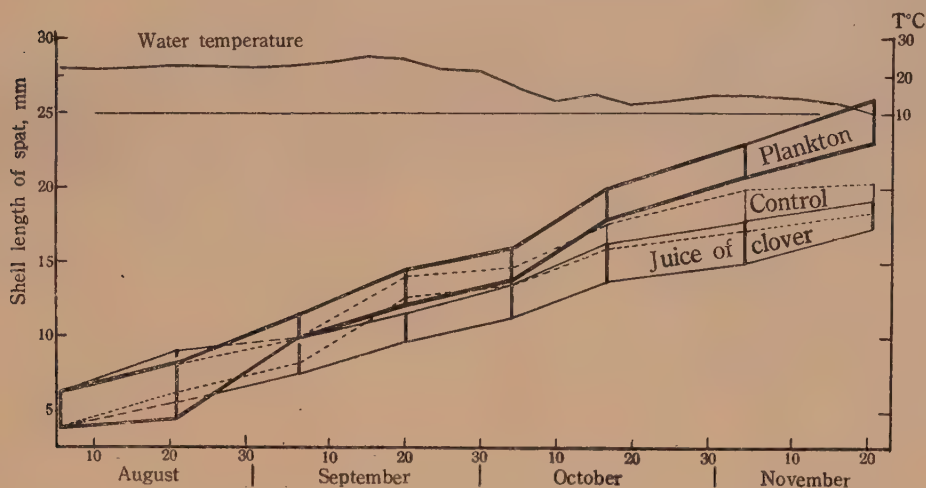


Fig. 1: The spat growth in tanks fed with plankton, juice of clover, and without feeding (control). Mean shell length measured at intervals of two weeks are shown in the confidence intervals in 90 per cent reliability. The sea water temperature of the tanks is shown at top.

The mortality and growth rate in each tank seem to vary considerably annually, judging from the results obtained in the past three years. Plankton and juice of clover, however, may be excellent food for rearing the scallop spat in tanks. The scallop spat in the control tank in the experiment showed considerable growth compared with those fed with juice of clover, and this may indicate that the detritus composed of decayed plankton are of importance as food of the spat as already pointed out in the oyster by Korringa (1949).

III. ON REARING IN THE POOL OF THE MARINE BIOLOGICAL STATION

The ground pool called "marine aquarium" of the Marine Biological Station covers about 48 square meters, and is surrounded with rocky walls and is connected with the sea by two side gateways. The bottom of the pool is covered with mud. The depth of the pool was 1.5 meters at high water and 0.6 meters at low water at the deepest point. The circulation of water depended upon the tidal currents and waves of the open sea.

The pool was tried first for rearing the spat in the season of 1954. About 15,000 spats of 3.2 mm in mean shell length were placed in the pool in late July and 1.0–1.5 kg of juice of clover was given every day.

The pool was covered with a marsh-reed screen for the protection against solar radiation. Therefore, the sea water temperature of the pool was not higher in fine summer days and the specific gravity of the sea water was not lower in rainy days than those of open sea water.

The pool water, however, was stirred up and became strikingly cloudy by the inflowing current at the time of every stormy weather. The spat seemed to be affected by the cloudy water and some of them died within a month. In late August spats were newly added again and the culture was continued. The spats grew and attained 9 mm in mean shell length (maximum 14 mm, minimum 7 mm) in late September.

Unfortunately, the spats were all buried in the bottom mud by the big typhoon of 26th September. This cloudy water caused by the stormy weather severely damaged the spat culture.

Based upon the experiments made in this season, another experiment is now being prepared for the next season.

SUMMARY

The attached scallop spats turn to bottom life in the stage of 6 to 10 mm in shell length. In these spats a high mortality has been recognized. These spats were placed in concrete tanks and reared by feeding with collected plankton, cultured diatoms, and juice of clover. Cultured spats presented respectively 15.5 per cent, 7.1 per cent and 35.8 per cent of mortality in plankton feeding, juice of clover feeding and control during four months. The mortality of the spats obtained in these experiments was very low, especially in the former two cases. The growth rates in these rearings are shown in Fig. 1, and the spats fed with collected plankton and cultured diatoms were comparable with those under natural conditions.

Scallop spats cultured in the ground pool showed considerable growth, but

these were damaged severely by the typhoon in late September, so that the results could not be as successful as was expected.

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REFRACTOMETRIC STUDIES ON THE HAEMOLYMPH IN
THE FASTING SILKWORM, *BOMBYX MORI* L.¹⁾²⁾

By

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(With 3 figures)

INTRODUCTION

So far as we are aware, little has been known of statistical analysis of the physico-chemical changes of the insect-haemolymph during fasting, applied to the separated two sexes or especially to the individual haemolymph of both sexes, as well as of the chemical changes of the insect-haemolymph under the experimental conditions of fasting.

Apart from the insect-haemolymph separated into two sexes here under consideration, Polimanti (1915) osmotically analysed the haemolymph or tissue fluid without the sex separation, in the fasting mulberry silkworm, *Bombyx mori* L., at the 37th-day period after hatching (the 5th larval stage). The freezing point depression of the fasted worm was 0.620 for the haemolymph and 0.720 for the tissue fluid, while that of the normal worm was 0.660 for haemolymph and 0.800 for tissue fluid. He concluded that the low values of these two fasted body fluids were caused by the lack or shortage of water and inorganic matter in their food of mulberry leaves.

Using the European milkweed moth, *Deilephila euphorbiae*, Moklowska (1929), by means of Pulfrich-Zeiss refractometer, analysed the haemolymph without the sex separation, in the induced fasting, together with the chemical changes of uric acid-, amino acid- and nonprotein-nitrogens.

Her results showed 1.3450 for the fasted haemolymph in contrast with 1.3508 for the normal haemolymph at the period of transition into pupation, and 1.3432 for the haemolymph of moulting and 1.3520 for the normal haemolymph.

¹⁾ Presented at the Semi-annual Meeting of the Kansai Branch of the Sericultural Society of Japan (Kyoto, April 3-4, 1953).

²⁾ Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

On the other hand, Kadohira (1928) and Sakurai *et al.* (1950) specific-gravimetrically analysed the haemolymph from some individuals of the separated two sexes of the fasting mulberry silkworm, *Bombyx mori* L., at successive periods of 24-hour intervals.

Using the haemolymph of both sexes fasted at the 3rd- and 4th-day periods of the 5th instar, both sexes living 12 days for the former and developing to the spinning period* for the latter, Kadohira showed some differences during fasting, between the haemolymphs of both sexes of fasting worms and of the normally developed worms of the control experiment. The fasting worms had low values and the normal worms had high values in corresponding sex and periods. He further showed the variation of sex-difference, with the relatively high values nearly constant in the female and the somewhat low values irregular in the male under the fasting at 3rd day period, and with high values in the female and low values in the male under the fasting at the 4th-day period.

Sakurai *et al.* (1950) performed other fasting experiments in the 4th and 5th instars at the beginning and the 3rd-day period of the 4th-instar larva, and at the beginning, the 3rd-day period and the 5th-day period of the 5th instar larva. Of these five experiments, in the first four the worms of both sexes lived for certain fasting periods and finally died, but those in the last experiment, fasted at the 5th-day period of 5th instar, lived to develop into pupae.

The specific-gravimetric determination of the haemolymphs was not undertaken at the further advanced fasting periods after the 4th-day period of the pupal stage.

As to the variation of the specific-gravimetric values of the sexually separated haemolymphs in the course of each fasting experiment, relatively high values of both haemolymphs usually appeared at the initial fasting period, then fell suddenly during the anterior half fasting periods, and slowly reached the lowest values at the end of the fasting period before death; while the initial values of the haemolymph in the last experiment varied with the age of fasting, being somewhat lower as compared with those of the control experiment. The lower values in the last fasting experiment were also noticed in each of the first four experiments when they were compared with those of the control experiment.

The sex-difference values at the initial fasting period, which appeared in each of the five fasting experiments, disappeared at the end of the fasting periods in the first four experiments, but remained in the last one at the 5th-day period of the 5th instar.

In previous refractometric studies on the individual haemolymph of the separated two sexes in the developing silkworm, *Bombyx mori* L., one of the

* No experimental data for further advanced fasting periods.

authors (Kobayashi, 1951, 1953) established statistically, together with the variation of sex-difference, the refractometric blood pictures of both sexes in normal development at successive periods from the 4th instar to the moth.

In the present experiment, the authors attempted to analyse the individual haemolymph of the separated two sexes in the fasting silkworms by the same refractometric method applied in the previous work and the experimental data obtained were also statistically analysed by the significant F-test (Snedecor, 1950).

MATERIAL AND METHOD

The materials used in this experiment were the mulberry silkworm, *Bombyx mori* L., the Chinese bivoltine strain (C. 108) which hatched out on May, 10. For the determination of the refractometric values of the individual haemolymph of both sexes, the Shimadzu Abbé type of refractometer with fourth decimal readings was employed.

The fasting experiments were carried out at the various developing periods of the 5th instar: (1) at the beginning, (2) the 2nd day period and (3) the 5th-day period. Normally developed worms were prepared for comparison with each of these three fasting experiments as the control.

Just after moulting, the 4th instar larvae were reared separated by sexes. To keep the same developing age, special care was taken to have a uniform size by selecting them at each boundary period in their metamorphosis, such as just after the 4th and 5th moultings, the spinning, the pupation and emergence.

For sampling the experimental materials, 10 individuals of each sex with uniform size were taken at random, and the individual haemolymph was drawn from a cut made by the insertion of a sharp dissecting needle into the integument at the fixed body region, *i.e.*, one of the paired abdominal legs of the larva, the dorsal vessel of the pupa and moth. The haemolymph thus obtained was placed directly on the surface of the measuring prism which was brought in contact with the illuminating prism. The determinations were carried out daily at 10-11a.m.

The refractometric values determined from 10 individual male and female haemolymphs at the corresponding developing periods were statistically analysed for variance between the fasting and normal developing, and also for sexual differentiation.

The values of the refractive index of the haemolymph determined at any room temperature were calculated like those at 17.5°C. (Nd 17.5°C.) (Kobayashi, Waku and Sumimoto, 1955; Kessler, 1928).

The age of the developing stage was expressed as zero at the beginning of the metamorphic boundary period.

EXPERIMENTAL RESULTS

The refractometric results obtained in these fasting experiments were compared with those of the control experiment of normal development to find out the differences between the mean refractometric haemolymph-values in each of the separated two sexes, male or female (A) and the sex-difference between the mean refractometric haemolymph values of both sexes, at their corresponding fasting and normally developing periods (B), with the significant F-test.

A. *The comparison of the mean refractometric values of haemolymph of each fasting experiment (a-c) with those of the control experiment of normal development, in each sex, male or female, at the corresponding developing periods.*

The results are given in Table 1, and Figs. 1 and 2.

Table 1

Variance analysis for F-test of the refractometric difference of male and female individuals at corresponding periods for the comparison of the fasting experiment and its control.

Abbreviations. L.: Larval stage, P.: Pupal stage, M.: Moth stage. V_1 : Variance between samples, V_2 : Variance within samples. The figures with the sign (—) in the difference column denoted the higher value in the control than in the fasted.

a). F-test—refractometric results in individuals fasted at the beginning of the 5th larval instar: control.

Female

Age		Degree of freedom	Mean refractometric value		Difference $\times 10^{-5}$	Sum of squares $\times 10^{-10}$	F-value	
Stage	Day		Fasted	Control			V_1/V_2	V_2/V_1
L.	0	18	1.34328	1.34388	.60	48160	6.73*	
"	1	"	1.34311	1.34416	-.105	32720	30.32**	
"	2	"	1.34341	1.34623	-.282	77460	92.41**	
"	3	"	1.34369	1.34866	-.497	83850	265.14**	

Male

L.	0	18	1.34325	1.34345	-.20	79050	2.19	
"	1	"	1.34276	1.34380	-.104	61290	10.88**	
"	2	"	1.34328	1.34440	-.112	45160	20.01**	
"	3	"	1.34292	1.34591	-.299	71850	111.98**	

b). F-test—refractometric results in individuals fasted at the 2nd-day period of the 5th larval instar: control.

Female

L.	2	18	1.34560	1.34623	-.63	75810	4.71*	
"	3	"	1.34703	1.34866	-.163	153210	15.61**	
"	4	"	1.34790	1.35035	-.275	285850	23.81**	
"	5	"	1.34798	1.35315	-.517	403400	59.63**	
"	6	"	1.34610	1.35586	-.976	417030	205.58**	
"	7	"	1.34665	1.35668	-.1003	372010	243.39**	
"	8	"	1.34661	1.36288	-.1627	335780	709.53**	
"	9	"	1.34674	1.35859	-.1185	594090	212.73**	

Table 1 (Continued)

Male

L.	2	18	1.34391	1.34440	-49	47170	4.58*
"	3	"	1.34544	1.34591	-47	135690	1.47
"	4	"	1.34573	1.34728	-155	235330	9.19*
"	5	"	1.34521	1.34899	-378	262650	48.96**
"	6	"	1.34464	1.35045	-589	295600	105.63**
"	7	"	1.34568	1.35079	-511	396630	59.25**
"	8	"	1.34445	1.35381	-936	567450	138.95**
"	9	"	1.34441	1.35279	-838	149600	422.48**

c). F-test—refractometric results fasted at the 5th-day period of the 5th larval instar: control.

Female

L.	5	18	1.35477	1.35315	162	174520	13.53**
"	6	"	1.35475	1.35586	-111	344940	3.21
"	7	"	1.35407	1.35668	-261	208090	29.46**
"	8	"	1.35639	1.36288	-649	640890	59.15**
"	9	"	1.35381	1.35859	-478	491520	41.84**
"	10	"	1.35128	1.35385	-257	219050	27.14**
P.	0	"	1.34983	1.35104	-121	149530	8.81**
"	1	"	1.35046	1.35211	-165	151750	16.15**
"	2	"	1.35145	1.35411	-266	410640	15.51**
"	3	"	1.35208	1.35455	-247	144980	37.87**
"	4	"	1.35153	1.35474	-321	186290	49.78**
"	5	"	1.35192	1.35368	-176	341790	8.16*
"	6	"	1.35052	1.35285	-233	323540	15.10**
"	7	"	1.34958	1.35266	-308	615300	13.88**
"	8	"	1.34926	1.35125	-199	313330	11.38**
"	9	"	1.34872	1.35094	-222	367930	12.06**
"	10	"	1.34578	1.34755	-177	183280	15.38**
M.	0	"	1.34756	1.35051	-295	82280	43.08**
"	1	"	1.35255	1.35403	-148	298810	3.18
"	2	"	1.35379	1.35782	-403	1294960	5.38*
"	3	12	1.35418	1.35863	-445	578870	16.07**

Male

L.	5	18	1.34942	1.34899	43	228160	1.37
"	6	"	1.34912	1.35045	-133	267060	5.90*
"	7	"	1.34882	1.35079	-217	156870	27.02**
"	8	"	1.34948	1.35381	-433	614050	24.47**
"	9	"	1.35052	1.35279	-227	211210	21.95*
"	10	"	1.35078	1.35234	-156	612540	3.58
P.	0	"	1.34835	1.34882	-27	123570	
"	1	"	1.34864	1.34940	-76	222000	2.34
"	2	"	1.34884	1.35062	-178	217200	12.51**
"	3	"	1.35007	1.35061	-54	87730	2.99
"	4	"	1.34959	1.35119	-160	157500	15.37**
"	5	"	1.35096	1.35196	-100	222020	4.05
"	6	"	1.35018	1.35120	-102	362210	2.46
"	7	"	1.35037	1.35218	-181	466010	6.33*
"	8	"	1.34906	1.35109	-203	651250	5.69*
"	9	"	1.34663	1.34884	-221	323900	13.57**
"	10	"	1.34709	1.34729	-20	81890	
M.	0	13	1.35706	1.36042	-336	1676640	1.02
"	1	9	1.36447	1.36097	350	718810	4.07
"	2	13	1.36477	1.36719	-242	1342840	10.65**
"	3	"	1.36549	1.36646	-97	1516960	

Highly significant, ** $P < 0.01$, * $P < 0.05$.

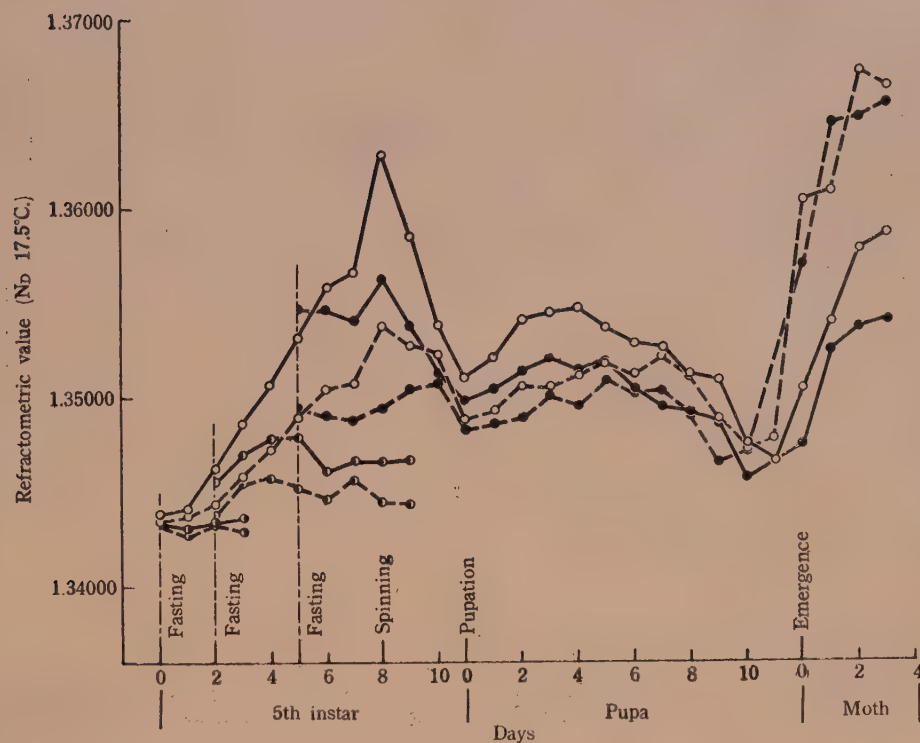


Fig. 1. Changes of mean refractometric haemolymph-values of both sexes at successive corresponding periods of three fasting conditions and of normal development (control); female—solid line, male—broken line.

○ : control, ○ : fasted at the beginning of 5th instar, ● : fasted at 2nd-day period of 5th instar, ● : fasted at 5th-day period of 5th instar.

1). The control experiment.

The general appearance of the refractometric blood pictures of the mean haemolymph-values of both sexes during the successive developing periods from the beginning of the 5th instar larvae to the middle of the moth stage, was found to be closely similar to those of the previous refractometric work of the normally developed worms (Kobayashi, 1951, 1953). i). 5th larval stage: In mean refractometric haemolymph-value, both sexes showed the lowest value without sex-difference at the initial period of the 5th instar, just after the 4th moulting; reached the peak with the highest values of spinning at the 8th-day period, showing the greatest sex-difference of the 5th larval stage, which was high in the female and low in the male, then decreased suddenly toward the pupation period at the 11th-day period, some amount of the sex-difference remaining at pupation. ii) Pupal stage: The lowered refractometric values of both sexes at pupation again increased gradually until highest and with the greatest sex-difference at the end of the anterior half of the developing period of this stage,

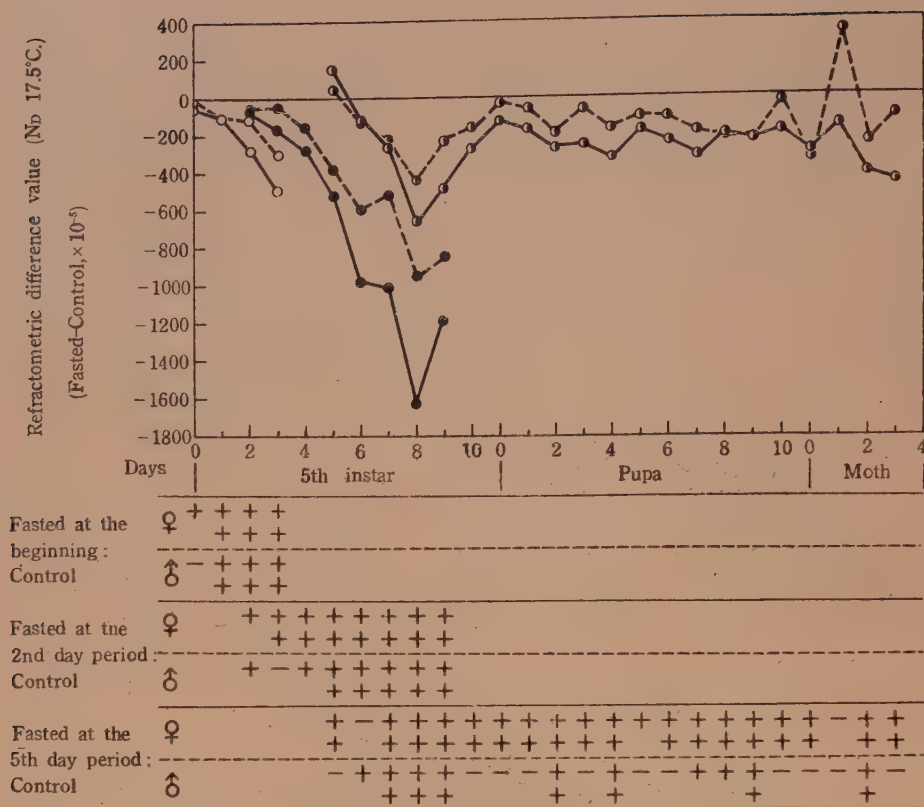


Fig. 2. Changes of refractometric difference between each of the three fasting conditions and of normal development (control), at the corresponding sex and period; female—solid line, male—broken line.

○: difference between fasted at the beginning of 5th instar and control, ●: difference between fasted at 2nd-day period of 5th instar and control, ⊙: difference between fasted at 5th-day period of 5th instar and control. ± denoting highly significant difference for $p < 0.01$ and + for $p < 0.05$; and — denoting insignificant difference.

then slowly decreased to the last day period of the pupal stage at the 11th-day period with the lowest values of both sexes for the period of emergence, where the sex-difference disappeared. iii) Moth stage: The lowest values of both sexes for the period of emergence promptly increased, exhibiting surprisingly the reversal of the refractometric values of both sexes, which became high in the male and low in the female, and reached the peak of highest values for both sexes at the 3rd-day period. The sex-difference was found to be greatest at the period of moth stage.

2) Fasting experiment.

a) Fasting at the beginning of the 5th instar. Both sexes remained alive

for three days. During these three fasting days, the mean refractometric values of both sexes at the initial period of the 5th instar, slightly decreased at the 2nd-day period and then slowly increased at the last 3rd-day period just before death; while those of the control experiment greatly increased during these three days, at the corresponding period of both experiments.

It was found from the results of the F-tests that the F-values in both sexes at the corresponding periods of these two fasting and control experiments were highly significant at $P < 0.05$ or 0.01 , with the exceptional insignificant values in the male at the 1st-day fasting period.

b) Fasting at the 2nd-day period of the 5th instar. Both sexes remained alive for seven days. During the anterior half periods of fasting from the beginning to the 4th- or 5th-day period, the mean refractometric values of both sexes at the beginning of fasting rapidly increased and reached the peak of the highest values at the 4th-day period for the male and at the 5th-day period for the female, then decreased with some amount of variation of the values of both sexes at the 6th- and 7th-day periods.

In both sexes, F-values for the difference between the two experiments of fasting and control at the corresponding periods were found to be highly significant through the majority of fasting periods, with the exception of insignificant values in the male at the 3rd-day period.

c) Fasting at the 5th-day period of the 5th instar. Both sexes fasted at the 5th-day period of the 5th instar were alive and developed to the periods of spinning, pupation, emergence and finally to the moth stage. It was found that the age of the pupal stage of this fasting experiment appeared one day earlier than that of the control experiment of normal development. With the exception of the high value in the male at the first day-period of the moth stage, the variation of mean refractometric haemolymph-values of both fasted sexes showed lower at the fasting periods of the 5th larval and pupal stages as well as the moth stage, exhibiting an approximate resemblance between the refractometric blood pictures of both sexes and those of the control.

Statistically, except for the occasional periods with the insignificant F-values of both sexes (the 6th-day period of the 5th instar and the 1st-day period of the moth stage for the female; the 5th- and the 10th-day periods of the 5th instar; the beginning, the 1st-, the 3rd-, the 5th-, the 6th- and the 10th-day periods of the pupal stage; the beginning, the 1st- and the 3rd-day periods of the moth stage for the male), the F-values for the difference in this experiments were found to be at a highly significant level.

It was shown from the results of the F-tests in each of these three fasting conditions that the period with the insignificant F-values at the corresponding successive periods in the male appeared to be much greater than those in the

female, especially in their distribution in the fasting at the 5th-day period, which seemed to be due to the less amount of difference-values between the two experiments of fasting and control.

B. The sex-difference between the mean refractometric haemolymph-values of both sexes at the corresponding period in the fasting and control experiments.

The results are given in Table 2, and Fig. 3.

Table 2

Variance analysis for F-test of the sex-difference at the various fasting periods of the 5th larval instar. Abbreviations. L.: Larval stage, P.: Pupal stage, M.: Moth stage. V_1 : Variance between samples, V_2 : Variance within samples. The figure with the sign (—) in the sex-difference column is denoted the higher value in the male than in the female.

a). Fasted at the beginning.

Age		Degree of freedom	Mean refractometric value		Sex-difference $\times 10^{-5}$	Sum of squares $\times 10^{-10}$	F-value	
Stage	Day		Female	Male			V_1/V_2	V_2/V_1
L.	0	18	1.34328	1.34326	3	80890		99.87
"	1	"	1.34311	1.34276	35	49330		2.23
"	2	"	1.34341	1.34328	13	70810		4.66
"	3	"	1.34369	1.34292	77	77930	6.85*	

b). Fasted at the 2nd- day period.

L.	2	18	1.34560	1.34391	169	71170	36.12**	
"	3	"	1.34703	1.34544	159	211130	10.78**	
"	4	"	1.34790	1.34573	217	384450	11.16**	
"	5	"	1.34798	1.34521	277	416930	16.56**	
"	6	"	1.34610	1.34464	146	463940	4.41	
"	7	"	1.34665	1.34568	97	622210	1.36	
"	8	"	1.34661	1.34445	216	323780	12.97**	
"	9	"	1.34674	1.34441	233	379050	15.53**	

c). Fasted at the 5th- day period.

L.	5	18	1.35477	1.34942	465	354850	72.59**	
"	6	"	1.35475	1.34912	563	363310	78.52**	
"	7	"	1.35407	1.34882	525	217530	114.04**	
"	8	"	1.35639	1.34948	791	675490	63.62**	
"	9	"	1.35381	1.35052	329	347090	27.99**	
"	10	"	1.35128	1.35078	50	663200		2.95
P.	0	"	1.34983	1.34835	148	99060	19.90**	
"	1	"	1.35046	1.34864	182	14230	20.95**	
"	2	"	1.35145	1.34884	261	236950	25.88**	
"	3	"	1.35208	1.34864	201	88170	41.24**	
"	4	"	1.35153	1.34959	194	158940	21.31**	
"	5	"	1.35192	1.35096	96	349300	2.37	
"	6	"	1.35052	1.35018	34	29010	2.79	
"	7	"	1.34958	1.35037	79	475970	1.18	
"	8	"	1.34926	1.34906	20	368730		10.24
"	9	"	1.34872	1.34663	209	504570	7.79*	
"	10	"	1.34578	1.34709	131	111850	13.81**	
M.	0	8	1.34756	1.35706	950	933260	19.36**	
"	1	"	1.35255	1.36447	1192	378080	48.10**	
"	2	"	1.35379	1.36477	1098	768200	31.38**	
"	3	7	1.35418	1.36549	1131	116257	24.47**	

d). Normally developed worms.

L.	0	18	1.34388	1.34345	43	46320	3.59	
"	1	"	1.34416	1.34380	36	44683	2.61	
"	2	"	1.34623	1.34440	183	51310	58.18**	
"	3	"	1.34866	1.34591	275	78220	87.02**	
"	4	"	1.35065	1.34728	337	136730	7.48*	
"	5	"	1.35315	1.34899	416	249120	6.25*	
"	6	"	1.35586	1.35045	541	248690	10.59**	
"	7	"	1.35668	1.35079	589	147430	21.17**	
"	8	"	1.36288	1.35381	907	579450	127.77**	
"	9	"	1.35859	1.35279	580	364640	83.03**	
"	10	"	1.35385	1.35234	151	168390	12.19**	
P.	0	"	1.35104	1.34882	222	194040	22.86**	
"	1	"	1.85211	1.34940	271	230450	28.69**	
"	2	"	1.35411	1.35062	349	390890	34.35**	
"	3	"	1.35455	1.35061	394	144540	96.66**	
"	4	"	1.35474	1.35119	355	184850	73.63**	
"	5	"	1.35368	1.35196	172	214260	12.41**	
"	6	"	1.35285	1.35120	165	395650	6.19*	
"	7	"	1.35266	1.35218	48	605340	2.92	
"	8	"	1.35125	1.35109	16	595800		25.85
"	9	"	1.35094	1.34884	210	487260	8.15*	
"	10	"	1.34755	1.34729	26	153320	2.52	
"	11	"	1.34664	1.34788	-124	487260	10.23**	
M.	0	"	1.35051	1.36042	-991	837850	105.49**	
"	1	14	1.35403	1.36097	-694	523330	36.82**	
"	2	18	1.35782	1.36719	-937	81120	97.41**	
"	3	"	1.35863	1.36646	-783	1490250	37.03**	

Highly significant, **p. < 0.01, *p. < 0.05.

1) The control experiment.

In this control experiment, refractometric variation of sex-difference values of the normal developing from the 5th-instar to the moth was found closely similar to that of the previous work (Kobayashi, 1951, 1953). The values of the sex-difference vary with the developing age accompanying the refractometric change of haemolymph-values of both sexes at the successive developing periods. With the exception of short periods with the lowest values of sex-difference, the value of the female was usually higher than that of the male in the 5th larval stage as well as the pupal stage but lower in the moth stage. i) 5th larval stage: The value of sex-difference was found to be lowest at the early periods of the 5th instar, then reached highest at the 8th-day period with a rapid increase, and suddenly fell to the lowest at the pupation period, some amount of sex-difference remaining. ii) Pupal stage: The sex-difference with the lowest value at pupation period again gradually increased and reached the highest at the end of the anterior half period of this stage, then slowly decreased and reached the lowest at the end of the pupal stage for emergence, where the high value of the female was replaced by the male at the following moth stage. iii) The moth stage: The sex-difference was lowest at the beginning of this stage, then reached the highest at the middle of the moth stage.

Except for the few insignificant cases at the periods with the lowest sex-difference, the F-values were found to be highly significant at $P < 0.05$ or 0.01

periods of the 6th- and 7th-day periods, the F-values were found to be significant at the high level with $P.>0.01$.

c) Fasting at the 5th-day period of the 5th instar. The refractometric sex-difference values of this fasting condition varied with the developing stages of the larva, the pupa and the moth, and closely resembled those of the control experiment. The same was also found in the variation of the F-values during the successive developing periods of this fasting condition.

Except for the specific period of pupation and some periods at the end of the pupal stage for the metamorphic boundary development, the F-values were found to be highly significant at $P.<0.01$ or 0.05 during the various stages from the larva to the moth. It was found in this fasting condition that the appearance of the periods with insignificant F-value, at the pupation and the end of the pupal stage, was much greater as compared with the control experiment. The presence of insignificant F-value at the pupation period was not demonstrated at the corresponding period of the control, and the periods with insignificant value were found to appear one day earlier as compared with the control.

CONCLUSION

From the results of the refractometric analyses of the individual haemolymph of the separated two sexes of the mulberry silkworm, *Bombyx mori* L., under three experimental fasting conditions of three different feeding periods in the 5th instar, the worms were found to live for three days under the fasting at the beginning, for seven days under fasting at the 2nd-day period and finally they died at the end of fasting. However, in contrast with those of the corresponding stage of normal development, both sexes fasted at the 5th-day period remained alive and developed into the pupa and moth without dying, by shortening their pupal developing period one day.

In comparing at the successive periods the changes of the mean refractometric haemolymph-values of both sexes under three fasting conditions with those of the normal development, it was found that the refractometric changes in the fasting at the 5th-day period of the 5th instar were closely related to the refractometric blood pictures of the normal development, but were absolutely different from those of the other two fasting conditions, (at the beginning and at the 2nd-day period of the 5th instar), by the fact that both sexes of the former developed into the pupa and moth, while both sexes of the latter, in each of the two fasting conditions, died at the periods near the end of fasting, showing peculiar refractometric blood pictures of both sexes for each fasting condition. Namely, in the haemolymph of both sexes, the former showed the pattern of the "partially or incompletely fasted" refractometric blood picture, and the latter the pattern of the "completely fasted" refractometric blood picture.

The results with the lower mean haemolymph-values of the physico-chemical changes under the various fasting conditions as compared with the controlled normal development, were already reported for the haemolymph, with and without the separation of sexes, of the mulberry silkworm, *Bombyx mori* L., which was analysed without statistical methods: for the haemolymph without sex separation, the osmotic values with 10 hours fasting at the 5th instar (Polimanti, 1915): for the separated haemolymph, the specific-gravimetric values when fasted at the 3rd- and 4th-day period of the 5th instar (Kadohira, 1928) and the specific-gravimetric values at the various periods fasted at the beginning and the 3rd-day period of the 4th instar, at the beginning and the 3rd-day period and finally the 5th day period of the 5th instar (Sakurai *et al.*, 1950). Kadohira and Sakurai *et al.* used the sampled haemolymph from two to five individuals, male or female, at the corresponding periods in each of their specific-gravimetric determinations.

Similar refractometric results with the lower haemolymph-values, 1.3450 in the fasted European milk-weed moth, *Deilephila euphorbiae*, was reported by Moklowska (1929) for the haemolymph without sex separation as compared with the haemolymph values, 1.3508, for normal development.

It was statistically shown from the results of the present experiment that under the experimental fasting conditions described above, the refractometric haemolymph-values of both sexes vary with the age of fasting to be usually lower than those of the controlled normal development, at the successive corresponding periods, not only at the 5th larval stage but also at the pupal stage, showing the sexual differentiation in the distribution of the significant or insignificant values in the separated two sexes in each of these three fasting conditions.

In the results of the specific-gravimetric changes of mean haemolymph-values of the separated two sexes, Kadohira (1928) showed that both sexes fasted at the 3rd-day period remained alive for twelve days, the change of both sexes exhibiting constant high values in the female and irregular low values in the male, with the occasional exception of similar values in both sexes; while both sexes fasted at the 4th-day period remained alive and developed to the spinning period with the sex-difference of higher values in the female than in the male. No description of the experimental data for the further advanced fasting period was given. Sakurai *et al.* (1950) reported on their results under the various fasting conditions at the 4th and 5th instar, that the initial relatively high values of both sexes fasted at the periods from the beginning to the 3rd-day period, rapidly decreased, showing some amount of sex-difference; but at the end of fastings the sex-differences disappeared at the periods before death, the lower values of the last fasting condition extending to the 4th-day period after spinning.

In comparing the refractometric and specific-gravimetric blood pictures of both sexes, drawn with the mean haemolymph-values under almost similar

fasting conditions at the 5th larval stage—the beginning, the 2nd-day period and the 5th-day period for refractometry; and the beginning, the 3rd-day period and the 5th-day period for specific-gravimetry—it was found that the former was characterized by the disappearance of the sex-difference at the short periods near the end of each fasting, while the latter usually maintained the sex-differences during the course of all fastings.

However, it was statistically shown by the significance of the F-test on the sex-difference at the successive fasting periods under these three experimental conditions that the sex-differences were insignificant for two days and significant at the last (3rd day) period in the first fasting, and were highly significant, with the exception of the insignificant F-values, at the 6th- and 7th-day periods in the second fasting, as well as at the 5th-day period in the third fasting except at the periods of the lowest mean refractometric haemolymph-values of both sexes at pupation and at certain periods of the end of pupal stage.

The sex-difference of the haemolymph seems to be present at the corresponding periods, varying with the age of fasting. The amount and the distribution of its significant values were shown to increase progressively with the advancing age of the feeding, when the fasting was settled at any of these periods, with the exception of some special fasting periods with insignificant value, such as the fasting condition at the beginning, and the pupation period fasted at the 5th-day period. It is considered possible that the occurrences of the insignificant values, which appeared under the fasting condition at the beginning of 5th larval stage, are closely related to those of the previous, 4th larval stage (Kobayashi, 1953) and that the insignificant values at the pupation period are due to the lesser amount of sex-difference.

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SUMMARY

Using the individual haemolymph of the separated two sexes of the fasting silkworm, *Bombyx mori* L., refractometric analyses were carried out at successive periods under three fasting conditions (complete fasting at the beginning and the 2nd-day period, and partial or incomplete fasting at the 5th-day period of the 5th instar) by means of the Abbé type of refractometer.

The refractometric data on the individual haemolymphs were statistically analysed with the significant F-test.

It was statistically shown by the results of this experiment that under the three fasting conditions, the mean refractometric haemolymph-values of both sexes vary with the age of fasting to be usually lower than those of the controlled normal development, not only at the 5th larval stage but also at the pupal stage. The age of pupal stage of the fasting experiment was found to appear one day earlier than that of the control experiment.

The sex-difference of the haemolymph of both sexes at the corresponding periods seems usually to vary with the age of fasting, its amount and distribution of significant values increasing progressively with the advancing age of feeding.

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THE EXISTING AND RAISED CORAL REEFS IN YORON ISLAND AND THEIR SHELL BEARING MOLLUSCS*

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(With 2 figures)

INTRODUCTION.

A scientific survey of the Amami-Oshima Group was carried out from the 17th of May to the 1st of June 1954 by the staff of the Kagoshima University. The present writer took part in the survey as a member of biological section, and made an investigation on the distribution of the shell bearing molluscs on the coral reef of Amami-Oshima, Kikaiga-shima, Tokuno-shima, Okinoerabu-jima and Yoron-jima (Yoron Island). Afterwards, from the 7th to the 22nd of August the present writer made the second survey exclusively on Yoron Island by himself.

Yoron Island is circumscribed by beautiful barrier reefs which characterize the island and is covered with raised coral reefs. It had been left outside of scientific investigation till the present surveys. This note is a preliminary report about the study on the recent and raised coral reefs of Yoron Island.

RECENT CORAL REEF.

Most of the recent coral reefs of Yoron Island are barrier reefs and some are fringing. Barrier reefs are beautifully represented on east, north and west sides of the island and fringing reefs on the southern coast. The barrier reef is formed along coast line with a proper gentle dip. The width of the lagoon becomes smaller as the dip of the slope becomes larger, and at last diminishes to zero, resulting in the formation of a fringing reef.

About the formation of the barrier reef, three hypotheses have been advocated. According to Darwin, the barrier reef is first formed as a fringing reef, which is converted into the former by the subsidence of the land. Against this subsidence theory, Vaughan advocated submergence theory. The lowering of sea-level

* Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

during glacial ages and its rise during interglacial were firmly ascertained by many modern geologists.

The third hypothesis advocated by Hobbs (1923) is based on the differential uplift and subsidence observable in the mountain arc, uplift of the front side and subsidence of the back side of the arc. This theory also starts from the fringing reef which is raised up in the front side to form a raised coral reef and is subsided in the back side to form a barrier reef. He explained the coral reef in Sunda and Marianne Arc as excellent examples of this type of reef formation.

Yoron Island is an islet which is one of the members of Ryukyu Arc. But here no proof of differential uplift and subsidence of land was observable. Also, it is not necessary to take up the subsidence or the submergence as fundamental factors of the barrier reef formation in Yoron Island.

In this barrier reef, the outermost part of the reef grows out into sea for about 10 meters in the form of comb teeth (Fig. 1, III and IV) along the edge of which living corals are found. Next, bases of the teeth unite with each other to form continuous flat surface. This area is about 15 meters in width (Fig. 1, II). Depressions are found here and there to form tide pools in which living corals are growing. These depressions are the remains of the spaces between old teeth. Next, the surface is elevated a little to form the highest region of about 10–20 meters in width. These measurements should be taken as to be rather rough and variable according to places.

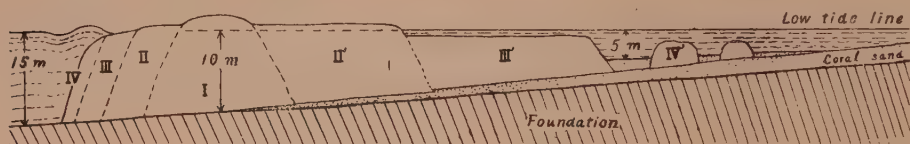


Fig. 1. Schematic illustration of a barrier reef in Yoron Island.

The part (I) may be conceived to be the part first formed. There must be some certain causes why this barrier reef was first formed at the depth of about 10 meters. And one of the causes must be the severe disturbance caused by waves in the shallow sandy water. Coral likes the sunshine and it was reported by Vaughan (1923) that it does not flourish in shadow. So, coral cannot flourish at the bottom of too deep dark water. These two may be considered as the most important factors which were necessary for the formation of the barrier reef of Yoron Island along the line of 10 meters in depth.

Part II' has a flat surface with the same level with II. According to Vaughan (1923), coral grows by far more rapidly in the calm water than in the wavy open-sea. Once shut in by the part (I) from the wavy open sea, coral grows rapidly in the lagoon. This is the reason why part II' is by far wider than part II. The

same can be said about the part III and part III', the surfaces of which are mostly under the low tide.

Further, one more important fact must be noticed concerning the form of the reef represented in Fig. 1. It is the fact that there occurred two slight uplifts of the land or slight lowerings of the sea level since the first barrier reef (part I) attained the sea surface; both less than one meter, maybe a half meter or so. Furthermore, it is said that glaciers reached a maximum in the nineteenth century and since that time have been shrinking at a very rapid rate and Gutenberg (1941) statistically showed the rise of sealevel of about 2.5 inches during the last one hundred years. Consideration about these facts may facilitate the understanding of the barrier reef of Yoron Island.

In lagoon, there are many living coral masses of irregular form under low tide level. And even a ship of 250 tons anchored on the open sea, 2 miles off Chabana, which is the only anchorage of the island. It was only 20 meter in depth at the anchoring place.

DISTRIBUTION OF THE SHELL BEARING MOLLUSCS ON THE SURFACE OF THE BARRIER REEF.

The whole surface of this barrier reef can be divided into three regions according to the fauna of the shell bearing molluscs.

The outermost region (Fig. 1, I, II and III) is covered with a lot of algae. In this part, Muricidae (especially *Drupa morum*, *D. albolabris* and *D. granulata*), Mitridae (especially *Mitra decurtata* and *M. litterata*), and *Ravitriona caputserpentis* are found most abundantly. All six species belonging to Iga-reishi (Nom. jap.) are found (from No. 1 to No. 6 of the following list), especially *Drupa morum* and *D. albolabris* being abundant. This region can be said to be characterized by these species and may be called the *area of Drupa*.

The greater part of II' in Fig. 1 is covered with thin layer of sand, one or two centimeters in thickness, which has been brought up by waves, whereas in the outer region it has been washed away also by waves. The sand gives a profound effect to the fauna of this region. *Conus*, especially *C. lividus*, *C. flavidus* and *C. ebraeus*, and *Strombus urceus* flourish instead of *Drupa*. And the inner half of this region are densely crowded with *Volsella auriculata* (Ryukyu-hibari-gai). Algae diminish both their amount and variety and small green algae are found scattered all over the surface. This region may be called *Conus region*.

The third and innermost part (III' in Fig. 1) of the reef is always under water. The surface is naked, lacking algae and is crowded with sea-urchin, *Echinometra mathaei*, *Helicoidaris crassispina*, *Triploneustes gratilla*, and *Heterocentrotus mamillatus* and some Ophiurida. In this area molluscs are not abundant. They are found in an extremely small density, only some species in the outerzone

migrating to this area (*cf.* List of Species). The only species which was found exclusively in this region was *Hydatina physis* and that only two individuals.

LIST OF SPECIES AND NUMBER OF INDIVIDUALS COLLECTED.

The following list is arranged in the order of families with more abundant number of individuals concerning the outermost *Drupa* region. Figures in the last three columns represent the number of individuals collected. The time spent for the collection of each regions was : *Drupa* region for an hour, *Conus* region for an hour and sea-urchin region for half an hour. The species names are taken from the Check List by Kuroda and Habe (1952).

List of species (Nomina japonica in parentheses)	Number of individuals		
	<i>Drupa</i> region	<i>Conus</i> region	Sea-urchin region
Fam. Muricidae			
1. <i>Drupa morum</i> (Röding) (Murasaki-iga-reishi)	279	12	0
2. <i>D. albolabris</i> (Blainville) (Shiro-iga-reishi)	92	4	2
3. <i>D. spathulifera</i> (Blainville) (Aka-iga-reishi)	13	19	0
4. <i>D. rubuscaesium</i> Röding (Hirokuchi-iga-reishi)	5	0	0
5. <i>D. ricina</i> (Linné) (Kimadara-iga-reishi)	4	4	2
6. <i>D. grossularia</i> Röding (Kiuro-iga-reishi)	2	9	0
7. <i>D. granulata</i> (Duclos) (Reishi-damashi)	355	54	17
8. <i>Drupella cornus</i> (Röding) (Shiro-reishi-damashi)	9	1	0
9. <i>Purpura tuberosa</i> (Röding) (Tsuno-reishi)	6	8	2
10. <i>P. kieneri</i> Deshayes (Tsuno-tetsu-reishi)	4	6	0
11. <i>P. intermedia</i> Kiener (Koibo-tetsu-reishi)	2	1	0
12. <i>Nassa francolinus</i> (Bruguière) (Hanawa-reishi)	0	1	0
Fam. Mitridae			
13. <i>Mitra decurtata</i> Reeve (Futokoro-yatate)	192	22	0
14. <i>M. litterata</i> Lamarck (Midare-shima-yatate)	41	18	2
15. <i>M. zebra</i> Lamarck (Ko-shima-yatate)	12	9	5
16. <i>M. virgata</i> Reeve (Chyu-shima-yatate)	9	6	0
17. <i>M. retusa</i> Lamarck (O-shima-yatate)	6	5	0
18. <i>M. chrysalis</i> Reeve (Mayu-fude)	1	5	1
19. <i>M. stictica</i> (Link) (Nishikino-kiba-fude)	0	4	0
20. <i>Pusia cancellarioides</i> (Anton) (Arare-otome)	2	6	0
21. <i>Vexillum exasperatum arenosum</i> (Lamarck) (Hama-zuto)	0	1	0
22. <i>V. pacificum</i> (Reeve) (Chijimi-hamazuto)	1	1	0
Fam. Cypraeidae			
23. <i>Ravitrona caputserpentis</i> (Linné) (Hanamaruyuki)	77	19	1
24. <i>Monetaria monetoides</i> Iredale (Kiuro-dakara)	1	34	2

25.	<i>M. annulus</i> (Linné) (Hanabira-dakara)	1	1	0
	Fam. Conidae			
26.	<i>Conus lividus</i> Bruguière (Iboshima-imo)	5	93	3
27.	<i>C. flavidus</i> Lamarck (Kinukatsugi-imo)	19	68	2
28.	<i>C. ebraeus</i> Linné (Madara-imo)	5	41	5
29.	<i>C. chaldaeus</i> (Röding) (Ko-madara-imo)	1	1	0
30.	<i>C. rattus</i> (Haiiro-minashi)	0	1	0
31.	<i>C. sponsalis</i> Bruguière (Hanawa-imo)	26	32	0
32.	<i>C. fulgetrum</i> Sowerby (Sayagata-imo)	1	10	0
33.	<i>C. coronatus</i> Gmelin (Juzukake-sayagata-imo)	0	3	0
34.	<i>C. catus</i> Bruguière (Arare-imo)	1	5	0
	Fam. Strombidae			
35.	<i>Strombus urceus</i> Linné (Mukashitamoto)	3	168	1
36.	<i>S. lentiginosus</i> Linné (Ibosode-gai)	0	1	0
37.	<i>S. luhuanus</i> Linné (Magaki-gai)	0	1	0
38.	<i>Lambis lambis</i> (Linné) (Kumo-gai)	0	2	0
	Fam. Vasidae			
39.	<i>Vasum turbinellum</i> (Linné) (Ko-onikobushi)	17	13	0
	Fam. Trochidae			
40.	<i>Trochus stellatus</i> Gmelin (Murasaki-uzu)	13	17	0
41.	<i>T. calcaratus</i> Souverbie (Hakusha-uzu)	3	0	0
42.	<i>T. maculatus</i> Linné (Nishiki-uzu)	1	26	0
43.	<i>Tectus maximus</i> (Philippi) (Sarasabatei)	0	2	0
	Fam. Bursidae			
44.	<i>Bursa bufonia</i> (Gmelin) var. (Okinishi)	9	12	0
45.	<i>B. corrugata</i> (Perry) (Unebora)	0	1	0
	Fam. Cymatidae			
46.	<i>Cymatium nodulus</i> (Link) (Shio-bora)	0	6	0
47.	<i>C. nicobalicum</i> (Röding) (Mitsukado-bora)	0	2	1
48.	<i>C. aquatile</i> (Reeve) (Satsuma-bora)	0	1	0
	Fam. Muricidae			
49.	<i>Murex rubicundus</i> (Perry) (Ganzeke-bora)	0	1	1
	Fam. Turbinidae			
50.	<i>Turbo stenogyrys</i> Fischer (Koshidaka-sazae)	2	1	0
51.	<i>T. argyrostomus</i> Linné (Chosen-sazae)	0	2	0
	Fam. Fascioliariidae			
52.	<i>Peristernia nassatula</i> (Lamarck)			
	(Murasaki-tsunomata-modoki)	1	9	0
	Fam. Buccinidae			
53.	<i>Engina mendicaria</i> (Linné) (Noshi-gai)	6	19	0

54.	<i>Cantharus fumosus</i> (Dillwyn) (Hora-damashi)	0	2	0
	Fam. Cerithiidae			
55.	<i>Contumax nodulosus</i> (Bruguière) (Onino-tsuno-gai)	0	1	0
56.	<i>C. columna</i> (Sowerby) (Ko-onino-tsuno-gai)	0	7	0
57.	<i>C. echinatus</i> (Lamarck) (Me-onino-tsuno-gai)	0	1	0
58.	<i>Clypeomorus chemnitzianus</i> (Pilsbry) (Kuwanomi-kanimori)	0	2	0
	Fam. Nassariidae			
59.	<i>Nassarius balteatus</i> (Lischke) (Yofubai)	0	2	0
	Fam. Hydatinidae			
60.	<i>Hydatina physis</i> (Linné) (Misu-gai)	0	2	0
	Fam. Mytilidae			
61.	<i>VolSELLa auriculata</i> (Krauss) (Ryukyu-hibari-gai)	4	216	2
	Fam. Pterriidae			
62.	<i>Pinctada panasesae</i> (Jameson) (Midori-aori-gai)	4	16	0
	Fam. Tridachnidae			
63.	<i>Tridachnes crocea</i> (Lamarck) (Hime-jyako)	2	0	0
64.	<i>T. elongata</i> (Lamarck) (Shiranami)	1	0	0
	Fam. Chamaidae			
65.	<i>Chama semipurpurata</i> Lischke (Somewake-gashira)	1	3	2
	Fam. Veneridae			
66.	<i>Venus reticulata</i> Linné (Ara-nunome-gai)	0	2	0

DISTRIBUTION OF RAISED CORAL REEFS.

Yoron Island is a small and flat islet of 6 km (EW) × 5 km (NS). The island is divided into three parts by two dislocation lines. One line runs from the north to the south and the other from near the highest points of the island to the east (Fig. 2).

The western part is the lowest and nearly horizontal. The raised coral reefs in this part are irregularly distributed all over the area except a part along the road of Riccho and rice fields. Along the Riccho road, the exposed foundations are exclusively composed of Palaeozoic metamorphic rock (roughly shaded part in Fig. 2). Whereas, the foundation rocks of raised coral reefs found in this part are all Palaeozoic limestone (marble) of bluish gray (Fig. 2, black dots). The northern half of this part was not thoroughly studied and is left to the future investigation.

The north-eastern part makes a slope with a gentle dip towards east and north, ending in a sandy shore. This part has several tiers of raised coral reefs. The topmost raised reef is a sheet of irregular contour (Fig. 2, I). The reef No. II, III and IV run parallel to the coast line, No. III being most beautifully represented as a small mountain range. It is called "Uro-sammyaku", which

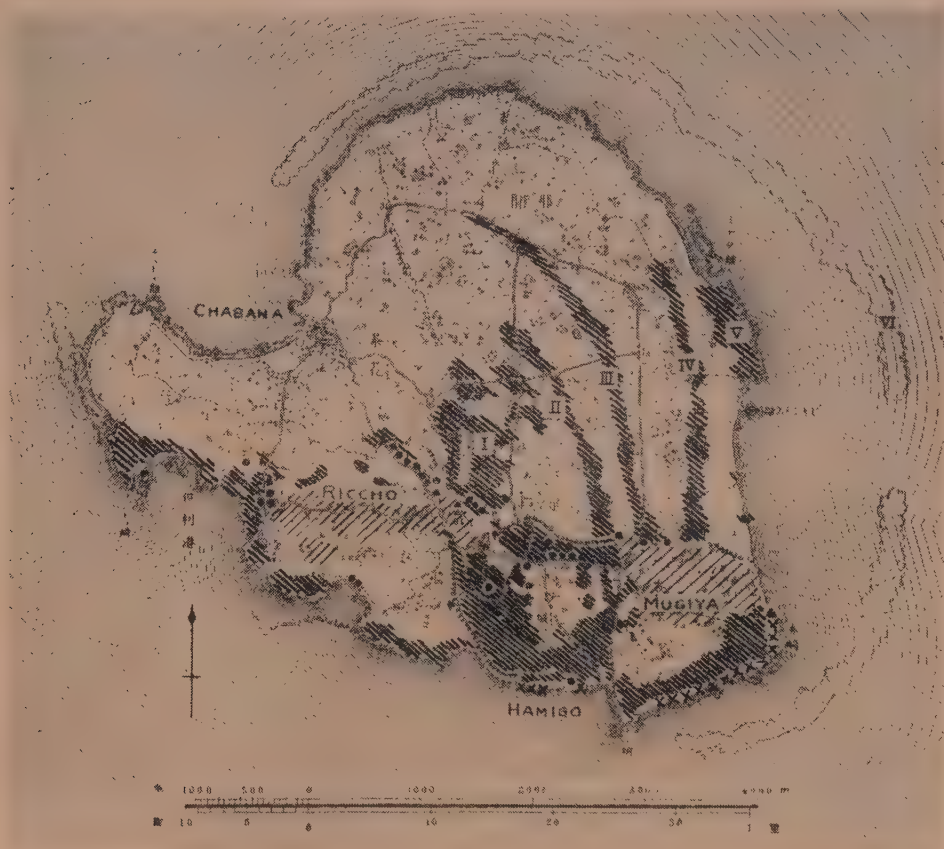


Fig. 2. Distribution of the raised coral reefs in Yoron Island. Densely shaded area : raised coral reef. Roughly shaded area : the area where lacks raised coral reef. Black dot : Palaeozoic limestone makes the foundation of the raised coral reef. Black triangle : ditto, Palaeozoic metamorphic rock. Cross : ditto, conglomerate:

means coral mountain-range. The planes intercalated between these coral elevations are cultivated as rice fields, which had been, it is certain, lagoons before each uplifts of the foundation. The northern half of this region was not studied thoroughly and is left to the future investigation.

The third region is a high terrace, makes a gentle slope towards south-east and ends at the coast line as a precipice. Raised coral reefs in this part are well developed. They are of irregular form and do not show such a beautiful arrangement as in the second region, except a beautiful terrace developed at Hamigo (Fig. 2). This is due to the fact that in this region the greater part of the reefs were formed as fringing reefs. It is a problem why in this part the barrier reef was not formed, in spite of its similar dip with the second part. The present writer wants to point out that there was no sand accumulation here, which disturbs, when

combined with waves, the formation of the coral reefs in the shallow water, except the central part of this region. The foundation rock of the raised coral reefs in the upper surface of this region was in most cases Palaeozoic marble (Fig. 2, black dots), and two cases were observed where Palaeozoic metamorphic rock makes the foundation (Fig. 2, triangle marks); whereas, at the coast line, it is conglomerate composed of the Palaeozoic pebbles (Fig. 2, cross marks), examples where Palaeozoic metamorphic rock and marble make the foundation being observed each only one case (Fig. 2).

In the northern half of Mugiya, no raised coral reef was found. Here, the foundation rock is Palaeozoic metamorphic rock. The present author will make clear the reason why there lacks raised coral reef completely in these two metamorphic rock regions, Riccho and Mugiya, in a future report.

MOLLUSCAN FOSSILS FOUND IN RAISED CORAL REEFS.

Many molluscan fossils are found in raised coral reefs. Most of them are casts and it is difficult to identify them. But some have preserved shells. The list of specimens which were identifiable is as follows. So far, no extinct species has been found.

Fam. Turbinidae	1. <i>Turbo stenogyrys</i> Fischer (Koshidaka-sazae)
	2. <i>T. petholatus</i> Linné (Ryuten)
Fam. Cypraeidae	3. <i>Lyncina vitellus</i> (Linné) (Hoshi-kinuta)
Fam. Vasidae	4. <i>Vasum turbinellum</i> (Linné) (Ko-onikobushi)
Fam. Mytilidae	5. <i>Lithophaga lithura</i> Plisbry (Kikai-ishimate)
Fam. Trapeziidae	6. <i>Trapezium oblongatum</i> (Linné) (Suehiro-funagata-gai)
Fam. Tridacnidae	7. <i>Tridachnes maxima</i> Röding (O-shiranami)
	8. <i>T. squamosa</i> (Lamarck) (Hire-jyako)
	9. <i>T. crocea</i> (Lamarck) (Hime-jyako)
Fam. Veneridae	10. <i>Venus reticulata</i> Linné (Ara-nunome-gai)

CHRONOLOGY OF THE RAISED CORAL REEFS.

H. Yabe and S. Hanzawa (1925) reported that the Ryukyu limestone was formed in the Prepleistocene epoch, against the opinion of A. Tokunaga (formerly Yoshiwara) who acknowledged the Pleistocene origin (1900). They investigated Foraminifera in the raised coral reefs, and found some species abundantly which live at the present time around the Philippines and in the southern tropical sea and not in the vicinity of Ryukyu Archipelago. Accordingly, they denied the origin of the raised coral reefs in the Pleistocene epoch, when it must have been kept at a lower temperature, glaciers prevailing. But since 1925, geological knowledges concerning the Pleistocene and Alluvial epoch has been advanced

and renewed in many points (Flint, 1952). Therefore, some discussion must be added about this problem. The facts which are related with the chronology of these raised coral reefs may be summarized as follows.

1. During the period from 8,000 to 6,000 years ago, it was warmer than the present time. The raised coral reefs at Tateyama in Chiba Prefecture, Japan, was constructed during this period. In this warm period, the sea-level was uplifted higher than at the present time. Accordingly, it is probable that the coral reef which was formed during this period must be situated on a higher level than the present sea-level. And in Yoron and other Ryukyu islands, it is highly probable that the raised coral reef now situated along the coast line (Fig. 2) must be the reef which have been formed in this period. The raised coral reef in this position was reported to have grown more rapidly than that in the higher position and the recent corals, the latter two having grown with nearly the same speed (Ma, 1934).

2. There were three interglacial ages of warm climate. It is estimated that the first interglacial age lasted for 75,000 years, the second for 150,000 years and the third for 100,000 years. The Alluvial epoch is the fourth interglacial and it is only 10,000 years since it began. If the raised coral reef along the present strandline was formed during the warmer periods at the beginning of Alluvial epoch, the recent coral reef should have been formed for these several thousand years and this is highly possible, as it was proved by Vaughan's observation on the living corals (1923). According to his estimation, the coral *Orbicella annularis* may be able to form a reef of 6 meters in thickness in 1,000 years under the climate of Florida and the West Indies. And if this is admitted it should be more certain that during by far longer interglacial ages coral reefs were made.

3. Uro-sammyaku (Fig. 2, III), the most conspicuous raised barrier reef, might be formed during the second interglacial age which was of the longest duration.

4. A well developed terrace at Hamigo might be formed in the same period with Uro-sammyaku.

5. In the Prepleistocene epoch, there was long period of the warm climate. It is also possible that the coral flourished during this period.

6. It may be correctly recognized that Yoron Island, which is a peak of a great mountain range, underwent some uplift during each glacial age, when the mountain-building process was active (Minato, 1954).

7. The molluscan fossils found in these raised coral reefs are all recent. Accordingly, these coral reefs cannot be very old.

From these facts, the following conclusion may be inferred. The summit of the island, which had been under the sea-level, rose up to the depth favorable for the growth of corals at some time during the long Prepleistocene epoch, and there the coral built the first reef (Fig. 2, I). During the first glacial age the foundation

was elevated, and the second coral reef (Fig. 2, II) was formed during the first interglacial age, then the third (III) during the second, the fourth (IV) during the third interglacial, the fifth (V) during the early Alluvial epoch and the sixth (VI), the present barrier reef, during these several thousand years.

Though the raised coral reefs in the third region do not show so beautiful arrangement as those in the second, it is sure that chronologically they must be the same; the topmost and the lowest raised coral reefs in this region being formed contemporaneously with the topmost and the lowest ones in the second region.

The raised coral reefs in the first region are scattered irregularly on the horizontal plane which makes us remind of the recent coral reefs which is being formed now on the horizontal sea bottom off Chabana.

RÉSUMÉ.

1. A new hypothesis has been advanced about the formation of the barrier reef. It was inferred that the barrier reef of Yoron Island was first formed along the depth of about 10 meters. It is due to the disturbance of the coral growth by stirring up of the sandy bottom by waves that the coral did not flourish in the shallow water, and it is due to the insufficiency of light that it did not flourish in the deep water. It must be noticed that the north-eastern part of the island, where the barrier reef is most beautifully represented, has a gentle dip and is accumulated with sand.

2. The sand brought up on the surface of the coral reef gives a profound effect to the association of shell bearing molluscs.

3. At least four uplifts of land and one lowering of sea-level were suggested by the investigation of arrangement of the raised coral reefs in Yoron Island, which were explained to be formed in Prepleistocene epoch, in three interglacial ages and in the Alluvial epoch. The shell bearing molluscs found in the raised coral reefs are all recent species. Accordingly, the raised coral reefs in Yoron Island cannot be formations of remote age.

ACKNOWLEDGEMENT

My cordial thanks are due to Mr. K. Nagai, the manager of the Museum of Kagoshima Prefecture, for giving me preliminary informations about Yoron Island and to Prof. Hatae and Mr. Ohba of the Geological Institute, as regards literatures and advices.

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GEOGRAPHICAL DISTRIBUTION OF ANIMALS IN THE JAPANESE
ISLANDS WITH SPECIAL REFERENCE TO AN AREA-FACTOR
AND TO THE CLOSENESS AMONG THE ISLANDS.*

By

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(With 4 figures)

It is a well known fact that the number of species appearing in an animal or a plant community varies with the area of the habitat observed. The number of species of a fauna or an animal group in islands has also been found to conform to the area of the island, *e.g.*, as butterflies in the Japanese islands (1). Recently the writer has studied the geographical distribution of several animal groups in the Japanese Archipelago and its adjacent islands and obtained the conclusions that the number of species of any group increases in proportion to logarithms of the area, that the biogeographical region can be settled by this relation, and that the coefficient of closeness proposed by Ôtuka (2) is very useful to the biogeographical subdivision. Regarding Cicadidae (3) and Manchurian Cerambycidae (4) the results have preliminarily been reported, and then those details are described regarding several other animal groups in the present paper.

RELATION BETWEEN THE NUMBER OF SPECIES AND THE
AREA OF ISLANDS (NAR)

For the relation between the number of species (y) which occur in a plant community and the area (A) where the survey was carried out, several formulae have been proposed by Arrhenius, Romell and Kylin. Of these formulae, Romell's one has been adopted to an insect-community in a grass land by Motomura (5) in the form of

$$y = a \log A + b. \dots\dots\dots (1)$$

where a and b are constants. Furthermore it has been found that (1) can be used to faunae in complicated tracts larger than the minor habitat occupied by an

* Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

animal community, e.g., to Cicadidae (3) and Manchurian Cerambycidae (4) distributed into the Japanese and adjacent islands, and here to mammals (6), (7), (8), (9), (10), reptiles (11), amphibians (12), (13), (14) (Fig. 1), Chilopoda (15), (16), Rhopalocera (1), (17) (Fig. 2) and Cladocera (18) (Fig. 3). On calculating the number of species in every groups, subspecies or varieties were included in the species to which they belong. But only in Chilopoda the number of genus was treated because of the source of data.

In the case of mammals the species, which are able to go across the sea or to be artificially brought to other islands, viz., marine and aerial animals, or several species of Muridae, *Rattus norvegicus*, *R. rattus*, *Mus molossinus*, *M. musculus*,

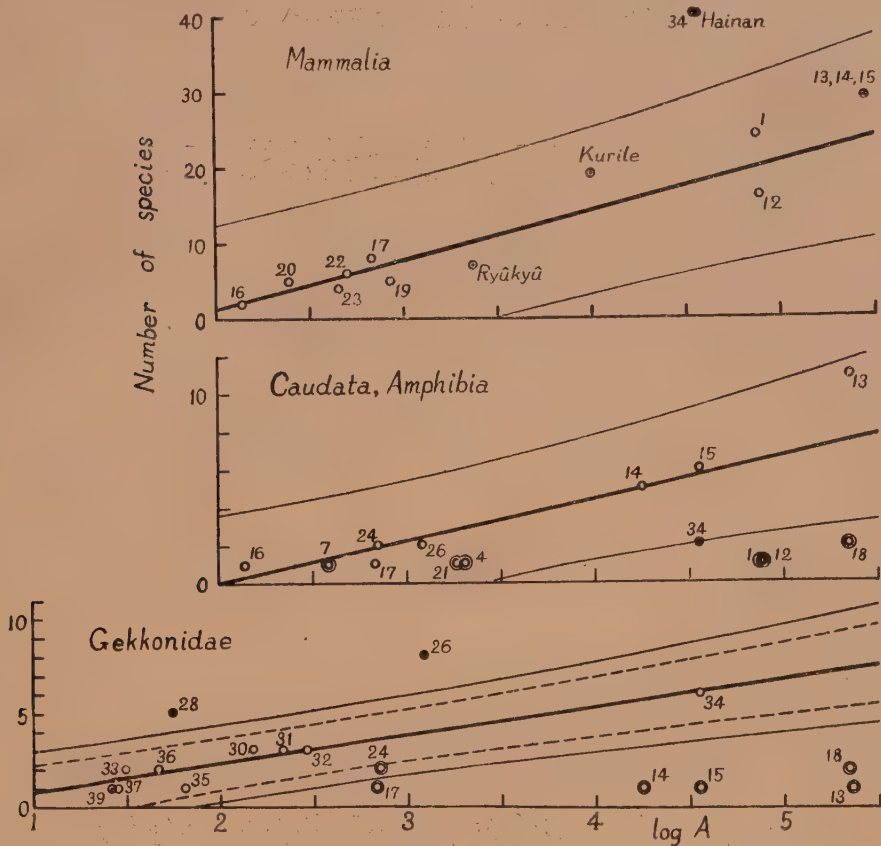


Fig. 1. NAR. The thick lines denote the formula (1), the thin the rejection limits at 1 % level of significance, and the broken those at 5 % level. Various sorts of point show distinction of the region except (●) in Mammalia. The figures attached to the points are the symbols of the islands corresponding to those in Table 1-6. In Mammalia (13, 14, 15) is the sum of Honsyū, Sikoku and Kyūsyū, and the values of the Kurile and the Loochoo are also the sum of several islands respectively.

M. caroli and *Apodemus geisha*, are excluded following Tokuda's (6) opinion. Therefore only the species taken as the aborigine were summed up.

For all kinds of animal groups here treated, the formula (1) has been proved to fit the case, and in every case several islands have been eliminated from the rejection-limits of this formula at 1 or 5 % level of significance, e.g., as Formosa and Hainan in Mammalia, and as Korea, Honsyû, Kyûsyû, Sikoku and Tusima rejected out of the lower limit and Okinawa and Kumezima out of the upper limit in Gekkonidae, and so on (Fig. 1-2). But in the case of Chilopoda Korea, Hokkaidô and Quelpart Island are together arranged in another NAR with Saghalien. In Rhopalocera Hokkaidô, Kunashir, Shikotan, Risiri and Rebun are included in another NAR differing from Honsyû group, and the Kurile Islands north of Iturup also belong to a group fitting in an NAR. However, among the islands smaller than 10 km² no correlation exists between the number of species and

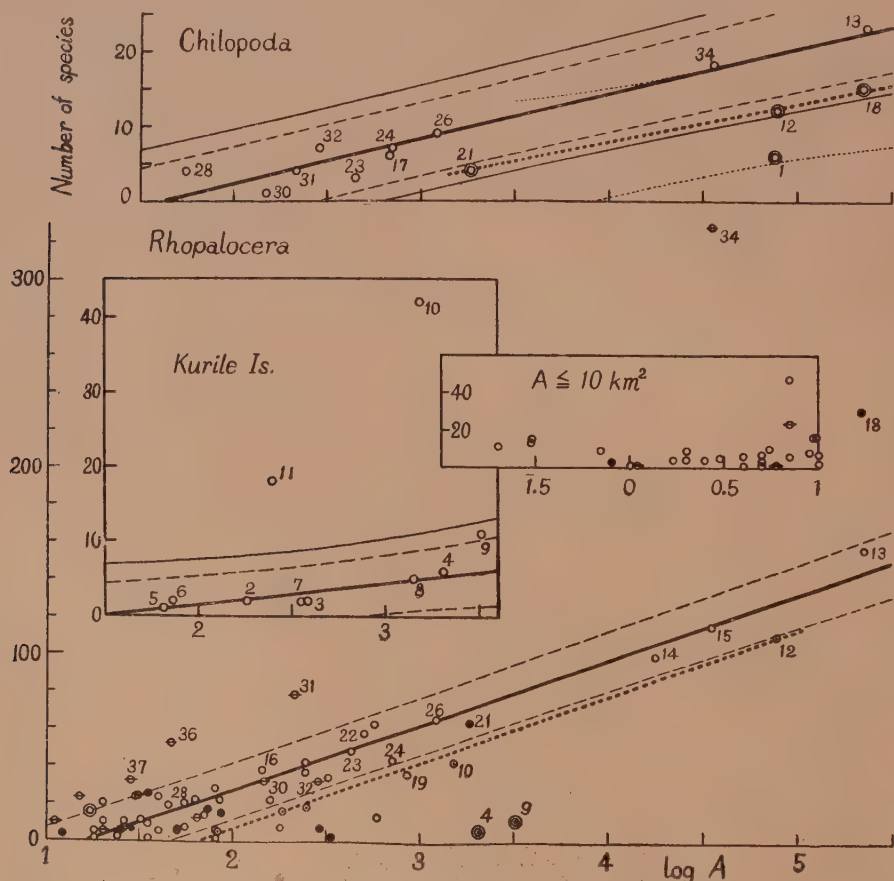


Fig. 2. NAR. The notation is the same as in Fig. 1, except that thick and thin, dotted lines show another NAR and its rejection limits respectively.

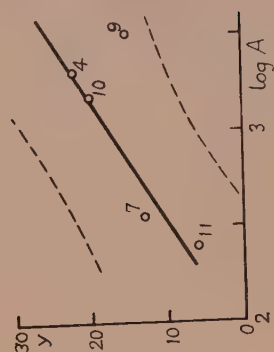
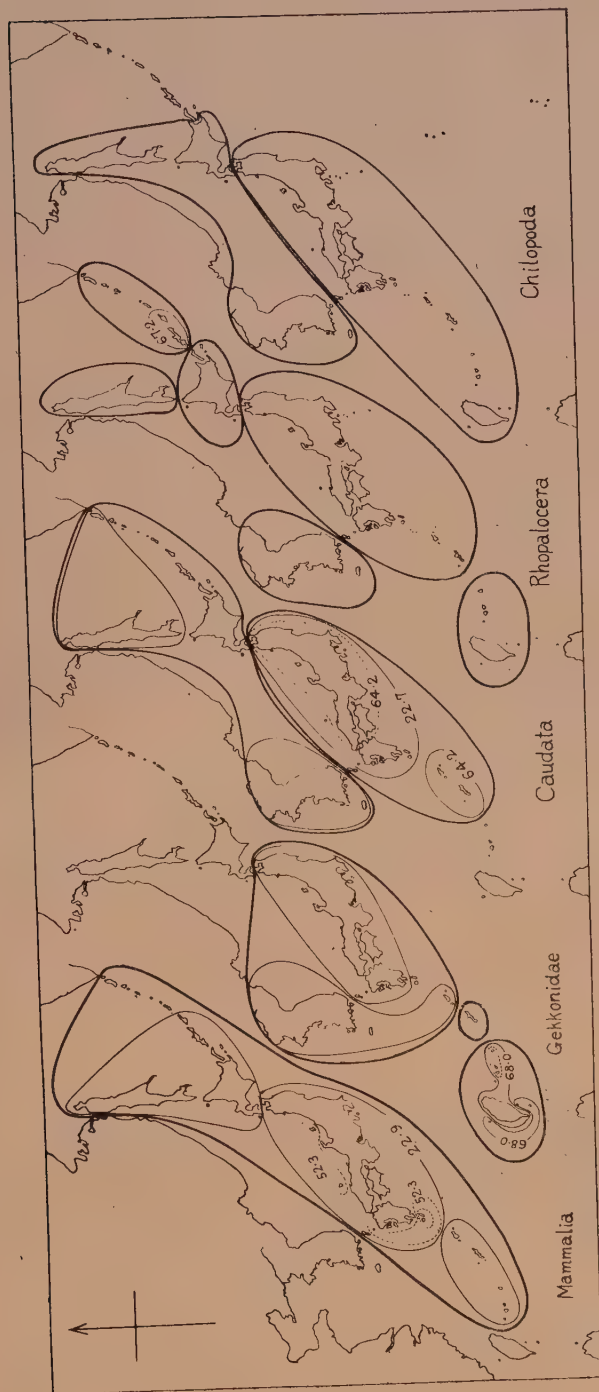


Fig. 3.

Fig. 3. NAR of Cladocera in the Kurile Islands.

the area (Fig. 2). Clandocera shows a trend of NAR in the Kurile Islands (Fig. 3).

From the results above mentioned, the ecological, geographical region has been decided as shown by the thick lines in Fig. 4 in view of the NAR as already discussed in case of Cicadidae (3). Hereafter it may be called the eco-geographical region or EGR. It is often difficult to classify small islands into EGR, for NAR has a tendency to converge into a certain range of small area and accordingly the intervals of the rejection limits of two regression lines overlap each other. But in many cases those islands can also be separated into respective regions from the view-point of their geographical locality.

SUBDIVISION BY MEANS OF THE COEFFICIENT OF CLOSENESS

In the same manner as previously shown on Cicadidae (3), EGR was further sub-divided by the method of the rejection-limit or by Thompson's method of rejection concerning the value of $p(=c/\sqrt{y_1 y_2})$, the coefficient of closeness (2), among the islands (Tables 1-6), where c is the number of common species and y_1 and y_2 are the number of species in each tract respectively. That is, an island being a centre, a set of p -values between the centre and the other islands is stratified by successive rejection of extreme values in the order of magnitude at 5 % probability level, supposing these values as approximately following the normal distribution. By this stratification islands may be classified into several groups. An unfavourable condition occurs, however, that several kinds of classification may appear as many as the number of the islands in question. But in many cases boundaries by these classifications coincided with each other so entirely or partly that the unified sub-division could be carried out. A part of the region thus divided may be called the "district", and this is further sub-divided into the "sub-district" by a single stratification repeated concerning a set of p among all islands within a district (Fig. 4). But unsurveyed islands or those of which data have not yet been obtained have been left out of consideration. Therefore these divisions may be revised in future.

DISCUSSION

The capacity of a definite area to accommodate a definite number of species or genera should be determined by a definite subjective environment of the animal in the habitat. The region having such an environment is to be considerably large. The island is in general a complicated environment of various topographic features. The topographic complexity brings various microclimates with various vegetations, but the range of climatic fluctuation is generally limited by the locality, *e.g.*, the latitude. Such a complicated environment becomes a habitat for various kinds of animal community. By every opportunity of distribution, the animal can invade a new habitat, which can maintain a certain community according to its

Table 1

Mammalia	Number of common species (c)														Number of species (y)
	1.	12	2-6	7-11	13-15	22	23	16	17	20	19	26 etc.	34		
1. Saghalien		13	3	7	1	0	0	0	0	0	0	0	0		
12. Hokkaidô	66.3		4	8	2	0	0	0	0	0	0	0	0		
2-6. North Kurile Is.	19.4	31.6		2	0	0	0	0	0	0	0	0	0		
7-11. South Kurile Is.	47.6	66.6	21.1		1	0	0	0	0	0	0	0	0		
13-15. Honsyû, Sikoku, Kyûsyû	3.8	9.3		6.2		6		2	6	5	5	2	2		
22. Yakusima	0	0	0	0	45.5		4	2	3	2	2	1	0		
23. Tanegasima	0	0	0	0	81.6			2	2	2	2	0	0		
16. Iki	0	0	0	0	37.1	57.7	70.7		1	1	1	0	0		
17. Tusima	0	0	0	0	26.3	35.3		25.0		3	2	1	2		
20. Okî	0	0	0	0	39.4	43.3		31.6	47.5		3	0	0		
19. Sado	0	0	0	0	41.5	36.5	44.7	31.6		60.0		0	0		
26 etc. Loochoo Is.	0	0	0	0	41.5	36.5	44.7	31.6				0	0		
34. Formosa	0	0	0	0	14.0	15.4	0	0	13.4	0	0	0	1		
					5.9	0	0	0	11.2	0	0	6.5			
Number of species (y)	24	16	10	9	29	6	4	2	8	5	5	6	40		

Table 2

Gekkonidae	Number of common species (c)															
	13-15	17	18	24	25	26	28	29	30	31	32	33	34	35	36	37
13-15. Honsyû, Sikoku, Kyûsyû	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0
17. Tusina.	100	70.7	1	1	1	1	1	1	1	1	1	1	1	0	0	0
18. Korea	70.7	70.7	100	2	2	2	2	2	2	2	2	2	2	1	1	0
24. Amami-ôshima	70.7	70.7	100	100	2	2	2	2	2	2	2	2	2	1	1	0
25. Tokunosisima	70.7	70.7	100	100	2	2	2	2	2	2	2	2	2	1	1	0
26. Okinawa	35.3	35.3	50.0	50.0	50.0	4	3	3	3	3	3	2	4	1	1	0
28. Kumezima	44.7	44.7	63.3	63.3	63.2	2	3	2	2	2	2	2	2	1	1	0
29. Iyezima	57.7	57.7	81.6	81.6	81.6	27.5	3	3	2	2	2	2	2	1	1	0
30. Miyakozima	57.7	57.7	81.6	81.6	81.6	21.2	51.6	66.7	100	3	3	1	3	1	1	0
31. Isigakizima	57.7	57.7	81.6	81.6	81.6	21.2	51.6	66.7	100	3	3	1	3	1	1	0
32. Nisimotozima	57.7	57.7	81.6	81.6	81.6	21.2	51.6	66.7	100	100	100	1	3	1	1	0
33. Yonakunizima	0	0	50.0	50.0	50.0	50.0	63.3	81.6	40.8	40.8	40.8	28.9	1	1	1	0
34. Formosa	40.8	40.8	57.8	57.7	57.7	57.7	54.8	47.1	70.7	70.7	70.7	28.9	1	1	1	0
35. Bôkotô	0	0	70.7	70.7	70.7	35.4	44.8	57.7	57.7	57.7	57.7	40.8	40.8	1	1	0
36. Botel Tobago	0	0	50.0	50.0	50.0	31.6	40.8	40.8	40.8	40.8	40.8	28.9	70.7	1	1	0
37. Samasna	0	0	70.7	70.7	35.4	44.8	57.7	57.7	57.7	57.7	57.7	40.8	100	70.7	0	0
38. Ogasawara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
39. Minami-daitôzima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
Number of species (y)	1	1	2	2	2	8	5	3	3	3	3	2	6	1	2	1

Table 5

Rhopalocera in the Kurile Is.		Number of common species (c)									
		2	3	4	5	6	7	8	9	11	10
p in %	2. Alaid		1	2	1	1	0	1	2	2	2
	3. Shumshir	50.0		2	0	0	0	1	1	1	1
	4. Paramushir	57.8	57.8		1	2	2	3	4	4	4
	5. Rashau	70.7	0	41.2		1	0	0	1	1	1
	6. Ketoi	50.0	0	57.8	70.7		1	1	2	2	2
	7. Simusir	0	0	57.8	0	50.0		2	2	2	2
	8. Urup	31.6	31.6	54.8	0	31.6	63.2		5	4	5
	9. Iturup	42.7	21.3	49.2	30.1	42.7	42.7	67.4		7	10
	11. Shikotan	33.3	16.7	38.4	23.6	33.3	33.3	42.2	49.7		17
	10. Kunashir	21.8	10.9	25.2	15.4	21.8	21.8	34.5	46.5	61.8	
Number of species (y)		2	2	6	1	2	2	5	11	18	42

Table 6

Cladocera in the Kurile Is.		Number of common species (c)				
		4	7	9	10	11
p in %	4. Paramushir		12	10	14	5
	7. Simusir	70.9		7	8	3
	9. Iturup	55.0	50.1		12	6
	10. Kunashir	66.7	49.6	69.3		5
	11. Shikotan	43.5	34.0	63.2	45.6	
Number of species (y)		22	13	15	20	6

adaptability or selectivity for the habitat in proportion to the locomotive ability. Each animal segregates its habitat so that an animal community should occupy a necessary space. The increase of the population density may accordingly bring an expansion of the living space.

Thus, it is natural that the number of species or genera which appears in the island, *viz.*, the bounded tract of land, is regulated by the area of the island as a measure of the space or as that of the complexity of environment, and the NAR has tentatively been found in the formula (1) existing in a definite region. From (1)

$$A \, dy / dA = a \quad \dots \dots \dots (2)$$

(2) means that the increase of the density of the number of species or genera is constant in any area within a definite region, *i.e.*, (2) is accepted as the potential capacity of the number of species or genera in the definite region. The constancy of the potential capacity in the definite region means that within this region the ecological and geographical factors for animal distribution are kept in a certain extent of homogeneity, *i.e.*, such a region is to be recognized as an EGR. It has been suggested that a fauna of a tract may invade an EGR according to the law of NAR (*e.g.*, Manchurian Cermabycidae into the Japanese Archipelago (2)) and

that the faunistic equilibrium brought by such mutual invasions of each native fauna among the tracts in- and outside of an EGR may come to be expressed by the NAR, (1).

Within an EGR limited by such a category, animal communities should be almost similar in any part of the region. However, because of that the area of the region is considerably large beyond the distribution of each species or genus limited within a comparatively smaller tract, and that such a tract of distribution is connected like a chain overlapping with each other, continuous faunistic gradients may be found from one end to another within an EGR, but in case of a group of islands they may be interrupted by the sea or straits. In fact a continuous change of fauna has been observed in the marine animals along the coast of Japan (19) where any factors for abruptness might scarcely exist. In this case, p is a function of the latitudinal difference, *viz.*, the distance from north to south. Environmental differences caused by the distance may be more important in the latitude than in the longitude. Therefore the interruption of p corresponds mainly to that of environment caused by the distance from north to south.

In the present case of land animals, p has been often discontinuous and stratified into several groups by several straits which may be barriers of distribution (Fig. 4). The sub-divided district or sub-district must have a homogeneous environment for an animal community containing the animal group in question.

The slope of NAR, a , takes a different value according to animal groups and to the EGR. The differences by the animal group may be caused by the differences of the subjective environment for each animal group, and those of the same animal group according to the EGR may come of the objective environmental differences among the regions. Generally speaking a southern region has a higher capacity than a northern one. But as regards Gekkonidae, Okinawa and its adjacent islands have a higher capacity than Formosan region lying south of the former does. This fact is perhaps a special case caused by the adaptability of this animal group for this region superior to that for Formosan region.

When $y = 0$ in (1), $A_0 = \log^{-1}(-b/a)$, and when $y = 1$, $A_1 = \log^{-1}\{(1-b)/a\}$. A_0 and A_1 means the critical area, *viz.*, the average area in which no species (genus) or only a species (genus) can live respectively (Table 7). It is very clear that in northern EGR both A_0 and A_1 are larger than in southern ones as seen in the values of Rhopalocera and Chilopoda. Although the potential capacity, a , is almost equal in Honsyû and Hokkaidô regions in Rhopalocera, the difference between A_0 or A_1 is markedly clear in both regions. It is also concluded that the animal with larger body, *e.g.*, Mammalia, has higher values in both A_0 and A_1 than that with smaller one, *e.g.*, the insect-groups, in the similar regions. But Caudata is an exception, for this animal group live in a particular environment of fresh water which is com-

Table 7

Animal group and EGR		a	$-b$	$A_0(\text{km}^2)$	$A_1(\text{km}^2)$
Rhopalocera	Honsyû Region	34.678	42.551	16.9	18.0
	Kurile R.	2.886	4.375	32.9	72.7
	Hokkaidô R.	35.140	64.895	70.2	75.0
Cicadidae ⁽³⁾	Honsyû-Korea R.	3.532	5.250	30.7	58.9
Cladocera	Kurile R.	15.510	29.109	75.2	87.0
Chilopoda	Honsyû-Formosa R.	6.026	9.896	43.7	64.4
	Korea-Hokkaidô R.	5.195	13.048	325.0	506.0
Caudata	Honsyû R.	2.226	4.479	102.2	288.3
Gekkonidae	Formosa R.	1.513	0.764	3.2	14.2
Mammalia	Honsyû R.	6.490	11.869	67.5	95.7

paratively rare and occupies only a limited area in a tract of land, and accordingly this group need relatively large tract in order to contain the environment necessary to live. On the contrary, Gekkonidae's values are very small, for the living space of this group living on trees or houses is very large even in a narrow tract. Consequently these critical areas are closely connected with the extent of niche of the animal group.

The boundaries of the geographical regions have ever been discussed by many biogeographers, until it comes to a conclusion that they differ according to animal groups and are merely convenient in order to distinguish the biogeographical regions (6), (20). In the present case too the geographical division is of statistical meaning that the homogeneity of the potential capacity and the closeness of fauna between islands is statistically stratified under a definite probability.

As regards Mammalia, Yakusima and Tanegasima are closely related to Iki as well as Oki is to Sado with a high coefficient (Fig. 4.). It may perhaps have been caused by an influence of the Tusima Warm Current, or by a closeness come of the similarity of the small area against the large islands as Honsyû and Kyûsyû. Such a case as the latter is also seen among the small islands around Formosa, viz., Bokotô, Botel Tobago and Samasna, regarding Gekkonidae. It is an interesting and peculiar phenomenon that as regards Gekkonidae, Amami-ôshima is closely related with Korea, but the cause is unknown. That Korea, Saghalien and Hokkaidô are closely connected as regards Caudata and Chilopoda probably depends on that these districts are located near the continent and under its influence.

Regarding Rhopalocera the formula, $y^2 = kA$, where k is a constant, had already been proposed by Nomura (1), but this formula was limited to fit in with islands below 600 km^2 . On the contrary the formula (1) covers a wider range of area except islets below 10 km^2 . And he has not used the data of many islands by reason of insufficient survey, but in my opinion the errors caused by the insufficiency of the survey are so small in many cases that they are contained within the range of the statistical errors in fitting the formula, e.g., in Honsyû region

only 5 of 37 islands fall outside of the 5 % rejection limit. The reason why the islets below 10 km² contain an exceeding number of species over the critical point is left to be clarified in future, but a small part of it may exist in a fact that several of these islets are so adjacent to main islands that the number of species may increase by migration.

SUMMARY

1) Regarding Mammalia, Gekkonidae, Caudata, Chilopoda, Rhopalocera, and Cladocera, the geographical distribution in the Japanese and adjacent islands has been discussed.

2) Between the number of species or genera (y) and the area of islands (A) the following relation exists in a definite region:

$$y = a \log A + b$$

where a and b are constant.

3) This formula means that the potential capacity with which the number of species or genera is maintained is constant in the ecogeographical region.

4) In general, the potential capacity is higher in southern regions than in northern ones. The critical area containing no species or only one species is generally smaller in southern regions than in northern ones. It may also be determined by the extent of niche.

5) By means of the stratification of the coefficient of closeness among the islands to ecogeographical region is divided into several districts and further into sub-districts. These biogeographical divisions show an extent with a certain ecological homogeneity in the habitat.

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ANATOMICAL OBSERVATIONS ON *ANOMIA CYTAEUM* GRAY¹⁾²⁾

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(With 5 Text-figures)

The present work was carried out under the guidance of Prof. Emeritus Dr. Hatai, when he was the director of the Marine Biological Station of Asamushi and I was a student. I hoped to continue the study and to publish the results in a more complete form, but the pursuit of the study in the same line has long been interrupted, so the author dares to publish the results, as far as obtained, on this occasion of the memorial number for the thirtieth anniversary of the Marine Biological Station of Asamushi. The author wishes to express his cordial thanks to Dr. Hatai for his kindness rendered to the author during the study.

MATERIAL

The total number of materials collected in the vicinity of the Station during my stay was 89. Among them, the largest one had the shell measurements: Height and Length of the left valve about 8 cm.

Systematic position.

Class	Pelecypoda
Order	Filibranchia
Superfamily	Anomiacea
Family	Anomiidae
Genus	<i>Anomia</i> Linnaeus
Species	<i>cytaeum</i> Gray.

METHOD

The following procedures were adopted:—

1. Gross topographical anatomy under the binocular microscope with the fresh or fixed materials.

Narcotic: Menthol.

¹⁾ Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

²⁾ Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 213.

Fixative: Formalin or Bouin's fluid.

2. Microscopical observation on the serial paraffin section (10–15 μ).

Material: Height and length of the shell were about 2 cm. long or less.

Fixative: Bouin's fluid or Zenker's fluid.

Stains: Borax carmin or Delafield's haematoxylin with eosin.

In this experiment, sections were made along the axis which corresponds to the direction of height or length of the shell. These sections can be regarded respectively to correspond nearly to the cross or horizontal sections of the animal body.

DESCRIPTION

Anomia is a Pelecypod with an internal and external asymmetry. Generally it is fixed to the rock in tidal zone, with the partly calcified byssus which projects to the right side through a hole in the flattened valve of that side (Fig. 3). Only in one case, a small *Anomia* fixed to the left valve of a large one was observed.

Shell. The form of the shell is modified by the ground on which it is settled down. But it may be said to be quite circular typically.

The left valve, that is the upper, is strong and stout, and is larger than the right valve, so that its margin overlaps the latter at all points.

The right valve, that is the lower, is flat and thin, and has a foramen through which the byssus projects (Fig. 2).

Muscle impressions in the interior surface of the valve:

The left valve has 4 muscle impressions. These correspond to anterior retractor muscle, byssal muscle, posterior retractor muscle and posterior adductor muscle respectively (Fig. 1).

The right valve has only an impression of the posterior adductor muscle (Fig. 2). In *Anomia*, the anterior adductor muscle is atrophied.

The relations of these muscles in the shell are shown schematically in Fig. 3.

Mantle. The mantle is divided into a right and left lobes asymmetrically, and has no suture between them. They extend along and inside the shell, covering and enclosing the whole body. The margin of the mantle presents reduplications, three in number, and is furnished with many tentacles.

Orientation of the Body. Now, we shall see the animal from the right side, after removal of the right mantle lobe (Fig. 4). In the middle, byssus is seen.

The mouth (15) is situated near the ligament of the shell. The anus (20) opens near the adductor muscle. Therefore, the antero-posterior axis is determined in general by the straight line through the ligament and the adductor muscle (9). Then, the side where the visceral mass lies is dorsal, and the side where the gill (2) runs is ventral. This orientation suggests the rotation of body from the normal

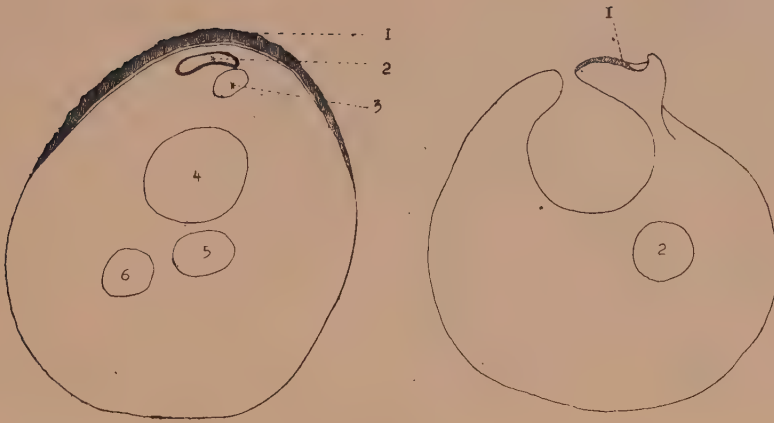


Fig. 1.

Fig. 2.

Fig. 1. *Anomia cytaeum* Gray, interior aspect of the left valve.

1. Exterior part
2. Ligamental fossa
3. Impression of the anterior retractor muscle
4. Impression of the byssal muscle
5. Impression of the posterior retractor muscle
6. Impression of the adductor muscle.

Fig. 2. *Anomia cytaeum* Gray, interior aspect of the right valve.

1. Ligamental fossa
2. Impression of the adductor muscle

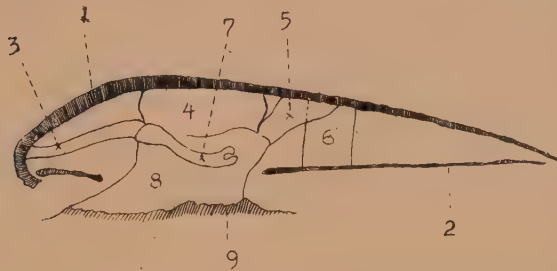


Fig. 3. *Anomia cytaeum* Gray, schematic diagram showing the reciprocal relation of muscles

1. Left valve. 2. Right valve. 3. Anterior retractor muscle. 4. Byssal muscle. 5. Posterior retractor muscle. 6. Adductor muscle. 7. Foot. 8. Byssus. 9. Rock.

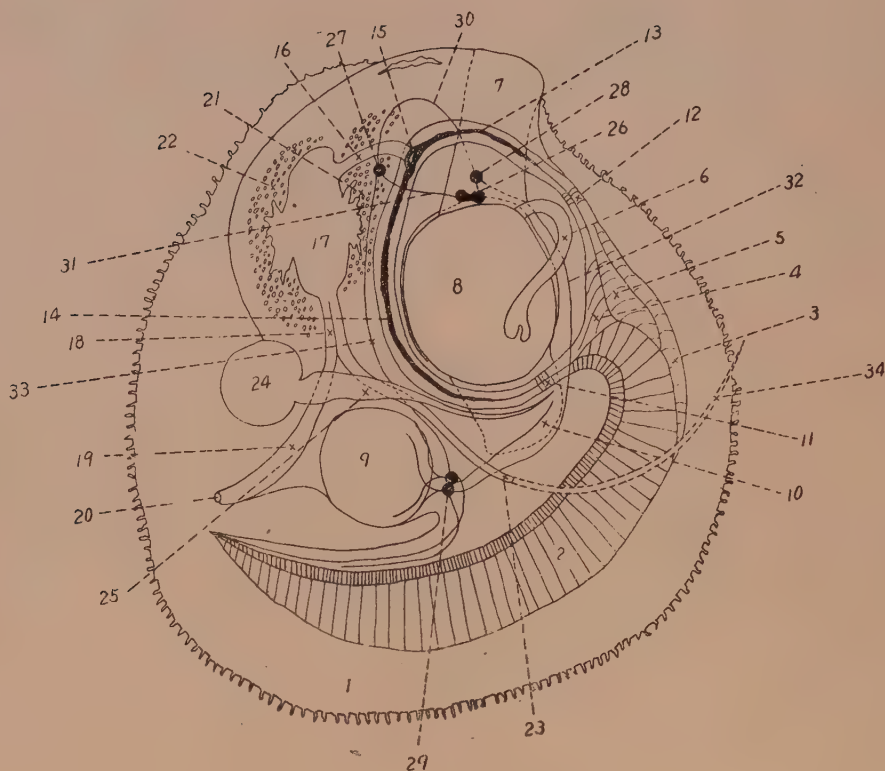


Fig. 4. *Anomia cytaeum* Gray, represented as seen from the right side, showing the internal organs after removal of the right mantle lobe.

1. Left mantle lobe. 2. Outer gill-plate of the right gill. 3. Outer gill-plate of the left gill. 4. Inner gill-plate of the right gill. 5. Inner gill-plate of the left gill. 6. Foot. 7. Anterior retractor muscle. 8. Byssal muscle. 9. Adductor muscle. 10. Posterior retractor muscle. 11. Right labial palp. 12. Left labial palp. 13. Left oral groove. 14. Right oral groove. 15. Mouth. 16. Oesophagus 17. Stomach. 18. Intestine. 19. Rectum. 20. Anus. 21. Left digestive diverticulum. 22. Right digestive diverticulum. 23. Crystalline style sack. 24. Ventricle. 25. Right auricle. 26. Pedal ganglion. 27. Right cerebral ganglion. 28. Left cerebral ganglion. 29. Visceral ganglion. 30. Cerebral commissure. 31. Right cerebro-pedal connective. 32. Left cerebro-visceral connective. 33. Right cerebro-visceral connective. 34. Crystalline style sack in the right mantle.

position of bivalve animals, about 90° angle around the axis which crosses the body and perpendicular to the shell.

This rotation is also observed in *Anomia ephippium* (Sassi 1905).

Moreover, considerable distortions occur among the various organs which are symmetrical in many other Lamellibranchs. Especially this is remarkable in the neighbourhood of the byssal muscle.

Foot and Byssus. Foot (Figs. 3 and 4) is much atrophied and has lost its locomotive function. It is attached to the antero-ventral side of byssal muscle, and is, in shape, roughly cylindrical with a sucker-like termination. It is very contractile, but, in fresh specimen, it is frequently observed to be stretched long and moved freely among various organs. Its function is not known as far as I am aware.

As to the byssus, when we remove calcified plug, it is observed at its base that many thin lamellae run parallel with each other, in the direction from the anterior retractor muscle to the posterior retractor muscle. Probably, the byssogenous glands may exist in the groove between them.

Gill. Both left and right bow-shaped gills (Figs. 4 and 5) run parallel with

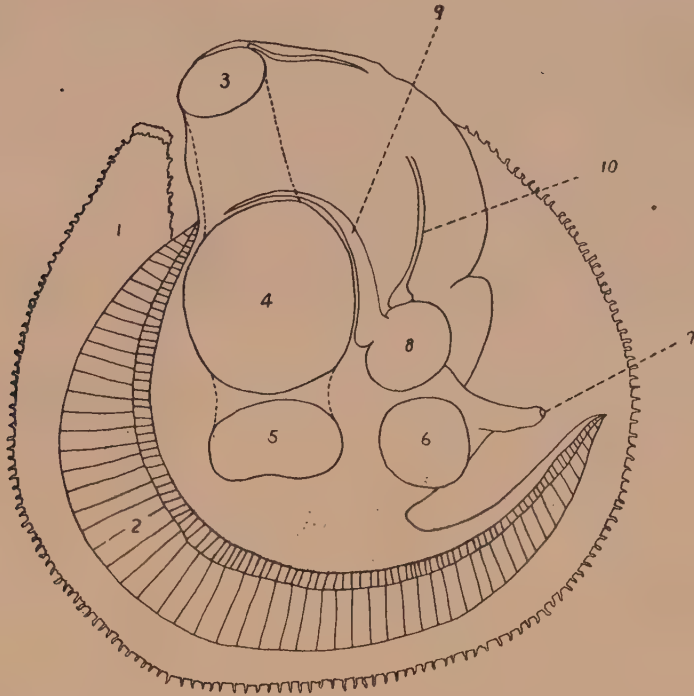


Fig. 5. *Anomia cytaeum* Gray, left-side view after removal of the left mantle lobe.

1. Right mantle lobe. 2. Left gill 3. Anterior retractor muscle
4. Byssal muscle 5. Posterior retractor muscle 6. Adductor muscle
7. Anus 8. Ventricle 9. Left auricle 10. Aortic trunk

each other on the ventral side. The left gill is a little longer than the right, because the left gill begins from the antero-ventral side of byssus, while the right gill begins from the postero-ventral side of it. The posterior extremities of both gills meet

at a point and project freely in the mantle cavity.

The gill is composed of both inner and outer gill-plates. Each gill-plate hangs downwards from the gill axis and then reflects upwards. The reflected borders of the inner gill-plates of either side are fused together in the middle line. On the other hand, the reflected part of the outer gill-plate is again reflected downward in the distal short end.

The anterior part of the inner gill-plate of the right side is stretched anteriorly toward the anterior extremity of left gill (Fig. 4).

Alimentary System. This is divisible as follows:—

1. Labial palp and Oral groove (Fig. 4).

A long ciliated groove runs around the byssus and ends on both sides, continuously with the anterior extremity of each gill. At these ends, several numbers of folds appear in the borders of the groove. These folds may be the vestiges of the labial palp which is remarkably developed in many other Lamellibranchs. Even in *Anomia ephippium*, a fairly remarkable labial palp is described in the figure drawn by Moriz Sassi (1905).

Then, except this folded portion, the remaining borders of the groove may correspond to the lips of other Lamellibranchs.

But to consider such formations as long lips in this case seems to be inadequate and I prefer to call this groove an oral groove.

I think the above-mentioned structures are peculiar to *Anomia*.

2. Mouth and Oesophagus (Fig. 4).

The mouth appears as a simple depression in the oral groove, and in the dorso-anterior direction to the byssus. This position of the mouth divides the oral groove into left and right asymmetrically. That is to say, the right oral groove is longer than the left.

The mouth continues to the oesophagus which opens to the stomach. The wall of the oesophagus is ciliated.

3. Stomach (Fig. 4).

The stomach is irregular in its form, somewhat long antero-posteriorly, and is lined with a ciliated wall. A pair of digestive diverticula, which are voluminous and acinous, surround it asymmetrically on both sides; left and right (they may be rather ventral and dorsal). Each digestive diverticulum provides its aperture to the stomach. The aperture of the left digestive diverticulum opens somewhat anteriorly to the right one.

About at the middle of the stomach, the gastric shield appears. It is said in Lamellibranchs that the tip of crystalline style is projected from its sack towards this shield.

At the posterior end of the stomach, both intestine and crystalline style sack open side by side. The former opens on the right side and the latter on the left

side.

The crystalline style sack contains the crystalline style, which projects into the stomach, and is richly ciliated on its inner surface. It runs posteriorly parallel with the intestine for a while, and turns postero-ventrally between the byssal muscle and adductor muscle. And then, in the neighbourhood of the visceral ganglia, it enters the right mantle lobe and ends blind within the mantle.

4. Intestine (Fig. 4).

The intestine has no convolution in its way. It runs posteriorly from the end of the stomach, parallel with the crystalline style sack for some distance. And then, it turns dorso-posteriorly, in the neighbourhood of ventricle, and becomes the rectum. The rectum opens to the anus on the dorsal side of the adductor muscle.

In the rectal portion, it is provided with an internal longitudinal ridge called typhlosole.

Circulatory System. It is said that the circulatory system of Lamellibranchs is not a completely closed system, but is a sinus system having no true vessels, except aortic trunk. In this animal also, there can be seen many sinuses in various parts of the body, but no clear vessel is to be traced. But there is a heart as the circulatory center (Figs. 4 and 5).

It is strange that the heart is not contained in the pericardium. The ventricle is a globular sack which projects freely in the mantle cavity, being attached with a part to the body wall, dorsally to the intestine. Therefore, its pulsation (21–27 per minute at 17–19°C) can easily be observed from outside of mantle cavity.

Both the left and right auricles are altogether asymmetrical and are also exposed in the mantle cavity.

The right auricle runs and extends from the ventricle towards the anterior basis of the right gill (Fig. 4). The left auricle is stretched from the ventricle towards the basis of the left gill, running along the dorsal margin of the byssal muscle (Fig. 5). The distal extremities of both auricles could not be discerned exactly, but it is supposed that the blood from the gill may enter the auricle.

At each aperture of the auricle to the ventricle, there can be seen the valves which may prevent the reflux of blood from the ventricle.

Only one anterior aorta is given off from the ventricle into the visceral mass (Fig. 5). This runs anteriorly and superficially on the left side of the visceral mass. The initial part of aorta is dilated as a comparatively large space, and, at its junction to the ventricle, is provided with a valve-like structure which may prevent the blood reflux to the ventricle.

The posterior aorta, which is present in many other Lamellibranchs, can not be seen in this animal.

Of *Anomia ephippium* also, Lacaze-Duthiers (1854) could find no cavity which

corresponded to the pericardium. He thought that the walls of the heart, pericardium and body might be fused together indiscernibly.

Both Paul Pelseneer (1891) and Moriz Sassi (1905) also could not find the pericardium of the same animal. But they found certain peculiar spaces in the body, which were connected with the excretory organs, though the results of observations on these spaces were entirely different among them. (Usually, the pericardium is connected with the excretory organs in Lamellibranchs).

In this work on *Anomia cytaeum*, I could not enquire into these points closely.

Nervous System. The situations of 3 pairs of ganglia (Fig. 4) were brought out clearly. On the left side of the anterior retractor muscle and near its base the pedal ganglia are situated. Both left and right ganglia are fused together in the middle. The left cerebral ganglion is situated a little anteriorly to the left pedal ganglion, and both are connected with a short left cerebro-pedal connective.

The right cerebral ganglion (27) is situated considerably apart from these ganglia above-mentioned. That is to say, near the oesophagus, at the position dorso-anterior and right to the right pedal ganglion. Therefore, the right cerebro-pedal connective (31), which unites the right cerebral ganglion and the pedal ganglion on that side, is much longer than the left connective (Fig. 4).

In general, the cerebral ganglia take supraoesophageal position in many other Lamellibranchs. But, in this animal, their situation seem to be infraoesophageal.

The visceral ganglia are situated on the ventral face of the adductor muscle(9). Both left and right ganglia are fused together closely and rather form a large mass.

Both cerebral and visceral ganglia are connected with the cerebro-visceral connectives (Fig. 4). The left connective runs ventrally along the left gill, while the right connective runs dorsally in the visceral mass and along the stomach and crystalline style sack.

The innervation from various ganglia could not be traced clearly. But it is observed that the pedal ganglia innervate the foot, the anterior retractor muscle, and the byssal muscle, and from the visceral ganglia nerves run to the adductor muscle, gills, posterior adductor muscle, etc.

REMARKS

Descriptions of sense-organs, excretory organs, generative organs, etc., are deferred until I shall have made more observations.

Among the various works on anatomical study of *Anomia*, only one paper: "Zur Anatomie von *Anomia ephippium*" by Moriz Sassi (1905) was accessible to the author. (In this paper, Sassi dealt mainly with the heart, the generative organs and excretory organs in detail). I could not, therefore, discuss the results of my observations sufficiently, but some comparisons with *Anomia ephippium* were made under the headings concerned.

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STUDIES ON THE REPRODUCTION OF HYDRAS
VIII. CAUSATIVE EFFECT OF LOWERING TEMPERATURE
ON THE SEXUAL MATURITY IN *HYDRA PARVA* ITÔ¹⁾²⁾³⁾

By

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(With 2 figures)

The writer already described that there were found two specific modes of occurrence of the sexual reproduction in the hydras, *viz.*, the warm type and the cold one, whose sexual activity may be favoured respectively by warmth and cold, and that autonomic sexual periodicity was found in both types though their detail rather differs from each other (Itô, 1954a, b, c).

Several species of the hydras, which had previously been reported in the present serial studies, were wholly dioecious, but *Hydra parva* has been known only as a hermaphroditic small-sized species from Japan and its sexual maturity has hitherto been observed frequently in fall in nature (Itô, 1947). Such being the species, the mode of occurrence of the sexual maturity in this species came into question. Thus, the environmental factors, chiefly the thermal one, to induce *H. parva* to the sexual reproduction were examined first by experimental mass cultures over a long period. The present paper deals with the results of these experiments.

MATERIAL AND METHODS

The animals were collected from a pond in Sendai in October 1952 and were used in the experiments after cultivation at laboratory temperature during about two weeks. The polyps taken at random from the stock cultures were placed in culture vessels, which were hard glass dishes of 90 mm in diameter and 45 mm in depth, together with filtered pond water, during the experiments.

The polyps were fed with a definite volume of small cladocerans and copepods, such as *Ceriodaphnia quadrangula*, *Bosmina longirostris*, and nauplius larvae of

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3) Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

Sinodiaptomus sarsi, every other day except the case of starved cultivation. The media were partly renewed by the fresh pond water, and the debris which accumulated at the bottom of the vessels was removed, at every observation.

Surplus polyps which were produced by the budding were removed from each vessel at every observation in order to maintain the initial number of the polyps throughout each experiment. To hold the desired experimental temperatures, the cultures were continuously placed in the thermostats or refrigerators.

The other details in each experiment will be stated in the following results.

RESULTS

Seven cultures, Cultures A to G, which were respectively composed of twenty polyps except Culture F of twenty-five ones, were prepared in the middle of October and these cultures were first placed in warmth ($21 \pm 2^\circ\text{C}$) for 30 days. No polyps formed the gonads in all the cultures during this period (Fig. 1, A to G).

Next, Cultures A to D were transferred to cold ($8 \pm 3^\circ\text{C}$) and Culture E to medium temperature ($14 \pm 2^\circ\text{C}$), while Cultures F and G were successively left in the warmth. Of these, Culture D was starved after the transference throughout its cold cultivation for 36 days, and Culture G was also starved during the second 30 days in the warm cultivation.

As the result, a few polyps in Cultures A to E came to develop transparent projections of immature testes and low swelling of immature ovary (Fig. 2, A) after 2 to 6 days from the above-mentioned transference (Fig. 1, b in A to E).

In Cultures A to D under the cold conditions, the polyps with the immature gonads rapidly increased in number and, consequently, the members in these cultures wholly came to form the gonads within subsequent 6 to 8 days (Fig. 1, b in A to D). While, in Culture E under the medium conditions, those with the immature gonads gradually increased, and then all the members also became sexual during subsequent 28 days (Fig. 1, b in E).

On the other hand, in Culture F, only two polyps developed the gonads on the 10th day and on the 12th day after the date of the transference in the above-stated cultures, but the polyps in Culture G remained quite sterile throughout the warm period (Fig. 1, F and G).

The above-said testes matured and they developed a large and stocky nipple at apex in about one week after their bulging and, thereafter, mature eggs were extruded from the body wall (Fig. 2, B) in about two weeks after the bulging of the ovaries. The extrusions occurred collectively within about ten days after the first extrusion in the four cultures in the cold, while they occurred rather dispersively over the longer period in Culture E at the medium temperature (Fig. 1, c and d in A, B, and E).

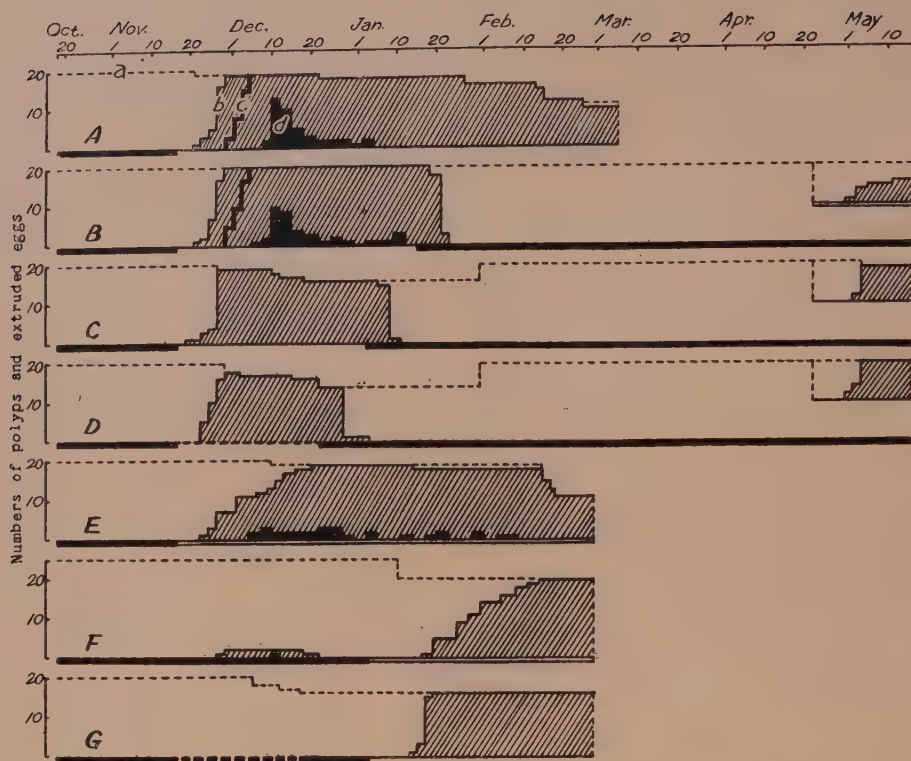


Fig. 1. Courses of various thermal and nutritive treatments and of the occurrences of the sexual reproduction in Cultures A to G.

■ Warmth ($21 \pm 2^\circ\text{C}$). — Cold ($8 \pm 3^\circ\text{C}$). - - - - Medium temperature ($14 \pm 2^\circ\text{C}$).

■■■■ Starvation in the warmth. - - - - Starvation in the cold.

(a) Total polyps. (b) Polyps whose immature gonads bulged.

(c) Polyps whose testes matured. (d) Extruded eggs.

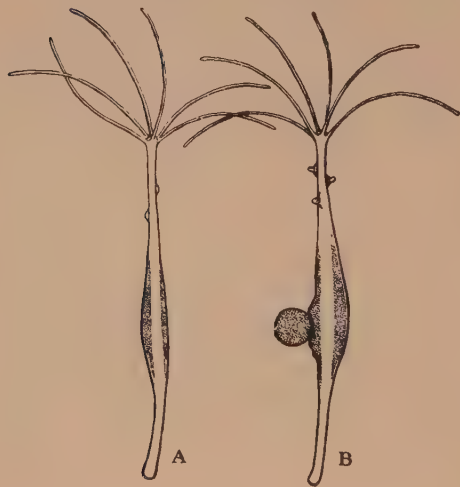


Fig. 2. *Hydra parva* with transparent projections of two testes and low swelling of an ovary (A), and with three mature testes, an ovary, and an extruded egg (B), from life.

Cultures D, C, and B were individually transferred to the warmth after 36, 48, and 61 days from the beginning of the cold cultivation, but the thermal conditions of Cultures A and E were left as they were.

In the former three cultures, the gonads quite disappeared from most of the polyps in about one week after the transference to the warmth, and, after that, the polyps remained wholly sterile throughout the warm period which lasted for about four to five months (Fig. 1, B, C, and D). Recoveries of the initial number of polyps in Cultures C and D, in the way of the warm cultivation (Fig. 1, Jan. 31 in C and D), were owing to supplements by several surplus polyps which have asexually been produced in each culture, for the good of the next experiments.

While Culture A was continuously left in the cold till early in March and all the polyps except one held their gonads at a stretch, no mature eggs were extruded after early in January. Culture E was also left at medium temperature till the end of February, and the polyps uninterruptedly maintained the gonads and the maturation of the eggs occurred scatteredly till early in February.

On the other hand, Cultures F and G, which had been successively left under the warm conditions, were separately transferred to the medium temperature and the cold on the 80th day after the beginning of the experiments. As the result, the sexual maturity was caused to all the polyps in the same course as the case of Culture E in the former and it was the same as the case of Cultures A to D in the latter, though their dates of the first bulging of the gonads were more delayed owing to the depression of the polyps caused by the sudden change of temperature.

Furthermore, respective halves of the members in Cultures B, C, and D, which had continuously been placed in the warmth after the first cold cultivation, were transferred again to the medium temperature (Culture B) and to the cold (Cultures C and D), and the respective remainders of them were left as they were in the warmth. The result was that the development of the gonads was induced in all the polyps of Cultures C and D and in 60% of the polyps by the 25th day after the transference in Culture B, in the similar manner to the cases of the first cold treatment, though the initial dates of the sexual induction were later than those of the latter.

In Culture B, the rate of the occurrence of the sexual reproduction stopped on the above-mentioned percentage. It was because the medium cultivation ended on the 25th day, and if the cultivation had been continued, the same rate as the former data shown in Cultures E and F would possibly have been obtained.

DISCUSSION

It became clear, from the above-mentioned results, that the sexual maturity may be induced by lowering temperature, regardless of the season, in *Hydra parva*

as was the case in the cold type, *Pelmatohydra robusta*, (Itô, 1954b), and that, thus, the fall of temperature may be one of the determining factors to cause the sexual reproduction in this species. In the present species, however, the induction does not always require to lower the temperature to the cold (ca. 8°C), namely, it may occur even by lowering it to the medium temperature (ca. 14°C), and the polyps may occasionally become sexual in the warmth, differing from the case of the cold type. The courses of the sexual induction and maturation are rather simultaneous and rapid in the cold treatment, while they are rather scattered and gradual in the medium one, and, thus, the former may be more stimulative to the occurrence of the sexual activity.

Judging from these facts, the mode of the sexual occurrence in this species may be considered as a transitional type between the cold type and the warm one as already reported (*supra cit.*), thus, the writer will call the type as *medium type*. The close relation between this mode of the sexual activity and the geographical distribution of this species, which extends over rather more southward than that of the cold type (Itô, 1947), seems also to be noteworthy phylogenetically.

On the other hand, no sexual maturity was induced by starvation, and the starvation in combination with the fall of temperature does not appear to cause such acceleration of the induction as was observed in *P. robusta* (Itô, 1954 b, c), at least in the present experiments.

The writer has hitherto observed that in nature, of this species, a large number of the polyps show the sexual maturity almost simultaneously in fall or early winter in this country, for example, of 128 individuals collected from a pond near Sendai early in November, 127 polyps were of sexual maturity. Such phenomenon in nature appears probably to be characteristic in this species as compared with those in other species, and it may also closely be connected with the above-mentioned results in the laboratory.

There have been known several species which are closely or relatively related to *H. parva*, such as *H. circumcincta* (P. Schulze 1917, Wunder 1928, etc.), *H. hymanae* (Hadley and Forrest, 1949), *H. utahensis* (Hyman, 1931), *H. americana* (Hyman, 1929), etc. However, no experimental work which analysed their sexual phenomena has been reported hitherto. Their sexual periods have been stated briefly in the taxonomic descriptions of them, which all agree to be fall, and Hyman (1931) stated that *H. utahensis* became sexual when transferred to the refrigerator, though not clear in details. It is possible from these facts that these related species are of the same type concerning the mode of the sexual occurrence as the present species.

The subjects about the duration of the sexual reproduction and the existence of the sexual periodicity and so on in this species will be discussed depending on the results obtained from experimental isolation cultures in the next paper of the

present serial studies.

SUMMARY

1. Causative effects of the thermal and nutritive factors on the sexual maturity in a hermaphroditic species, *H. parva*, were studied by experimental mass cultures during about seven months.

2. The sexual maturity may be induced at an extremely high rate by lowering temperature from warmth (ca. 21°C) to cold (ca. 8°C) or medium (ca. 14°C) regardless of season.

3. The polyps wholly came to develop the gonads within about one week by the cold treatment and within about one month by the medium one.

4. The testis matured in about one week and the mature egg was extruded in about two weeks, after their bulging in the cold.

5. In the cold or the medium temperature, the polyps continuously held the gonads during a long period, but the gonads disappeared in about one week by transferring to the warmth.

6. In the warmth, the sexual maturity only occasionally occurred and this was not caused by starvation, and the induction was not accelerated by starvation in combination with the cold treatment.

7. The mode of the sexual occurrences in *H. parva* may be considered as a transitional type between the cold and the warm ones (Itô, 1954 b), and is to be called as *medium type*.

The writer wishes to express his hearty thanks to Prof. M. KATÔ, Tôhoku University, for his encouragement and critical reading of the manuscript, and to Prof. T. OHUYE and Mr. Y. FURUKAWA, Ehime University, for their kindness and aid in carrying out the present study.

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COLONY FORMATION OF A LIMPET, *ACMAEA DORSUOSA*
GOULD, AND VARIATION OF LEVEL OF THE COLONY.*

By

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(With 2 figures)

INTRODUCTION

A limpet, *Acmaea dorsuosa* GOULD, forms a colony on the rock over the high water marks in spring and in summer and shows homing behavior (Abe, 1931). But since the middle of September, the limpet shows dispersion from the colony, and migrates upward, but since the time of snow fall, it migrates downward and continues the life in winter. But in the next spring, the colony of the limpet is formed newly with new members added, though one part of them returns exactly to their original home of the former year. (Abe, 1933)

I have found that the levels of colonies are somewhat changed in 1952 to 1954 compared with the positions of colonies formed in 1931 and 1932. And I have examined the reason of variation of level of colony, and therefore I wish to explain the results of my observations. The present observations have been made at the Asamushi Marine Biological Station since 1952 to 1954.

Before going further, I wish to express my sincere thanks to Prof. Dr. Shinkishi Hatai for his kind guidance on all my studies done since 1931 to the present time.

I GEOGRAPHICAL NATURE OF POSITIONS OF THE OBSERVATION

I have examined all the colonies formed on Hadakajima, a little island situated on the western seashore of the Biological Station. Hadakajima means "Naked Is land" and its topography is shown in Fig. 1.

As is shown in Fig. 1, Hadakajima is of somewhat square form, and colonies of the limpet are formed mainly on the rocky shore facing northward, namely on the shore from St. 1 to St. 3 in Fig. 1, and no colony is seen on the other shore of the island. And there stands a massive rock of about 32 metres in height in the

* Dedicated to Professor Emeritus Dr. Shinkishi Hatai, the founder of the Marine Biological Station of Asamushi.

middle part of the island.

II VARIATION OF NUMBER OF INDIVIDUALS AND NUMBER OF COLONIES

Colonies formed on the rocky shore of Hadakajima were photographed in

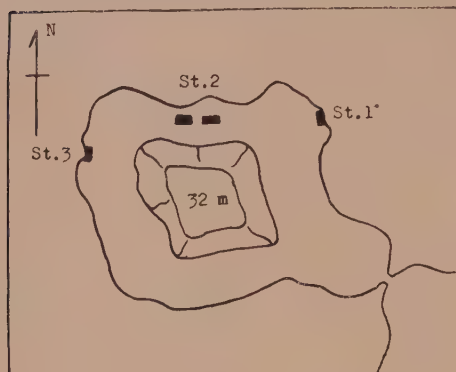


Fig. 1 Topography of Hadakajima.

1932, and their positions in 1932 can be compared exactly with the positions of colonies at the present time. The number of colonies and individuals in 1932 was compared with that at the present time, and the results are shown in Table 1.

As is shown in Table 1, the number of colonies has increased by about 2.8 to 3 times during the period from 1932 to 1954, while the number of individuals increased only by about 14 to

18% during these 21 to 22 years.

Table 1

Comparison of the numbers of colonies and individuals of the limpet,
Acmaea dorsuosa GOULD.

Year	Relative positions of the colonies							
1932	(21)		(102)		(26)	(0)	(15)	(19)
1953	(19) (17)	(4) (14)	(10) (9) (67)	(26) (14)	(26)	(24) (6)	(16) (7)	
1954	(19) (16)	(3) (4)	(9) (66)	(22) (12)	(34) (4)	(22) (12)	(16) (31)	

Year	Relative positions of the colonies	No. of colonies	No. of individuals
1932	(170)	6	353
1953	(22) (94) (28)	17	402
1954	(18) (96) (20) (11)	18	419

III VARIATION OF LEVELS OF THE COLONIES

Colony of the limpet is formed just above the high water marks as already stated. (Abe, 1931, '33) But the levels of colonies formed in the years 1953 and 1954 are different from that formed about 20 years before, and degrees of variation of levels of the colonies is also different according to stations in Fig. 1. And the levels of colonies in each station are shown in Table 3.

In Table 2, -6 cm shows that the colony is formed 6 cm lower than the standard level, namely the upper margin of the colony formed in 1932, and +35 cm

Table 2

Compariosn of levels of colonies formed in 1953 and 1954 to the levels of colonies formed in 1932.

Station No.	Standard level in 1932	levels of colonies in 1953		levels of colonies in 1954
1	0	-6 cm,	-9 cm	-7.2 cm
2	0	0 cm,	-3.9 cm	0 cm, 0 cm
3	0	0 cm,	+33 cm, +43 cm	0 cm, +33 cm, +35 cm, +43 cm

shows that the colony is formed 35 cm higher than the colony in 1932, and so forth.

Therefore it is clear that the level of colony was lowered about 6 to 9 cm in St. 1, but remarkable change was not seen in St. 2. But new colonies were formed at the levels of 33 to 43 cm above the former level in St. 3. Moreover, I have compared the level of colonies of the limpet formed in 1954 to the level of *Mytilus crassitesta* LISCHKE, though the latter species shows the remarkable increase of numbers and its distinct zone is shown in Fig. 2.



Fig. 2 A colony of the limpet, *Acmaea dorsuosa* GOULD (a) and the *Mytilus crassitesta* zone (m). (photographed in August, 1954).

The distance from the lower level of the colony of the limpet to the upper level of the *Mytilus* zone is measured in Stations 1, 2 and 3 and the results are shown in Table 3.

In Table 3, it is clearly seen that the distance of colonies from the *Mytilus* zone is different according to Station, namely the distance is largest in St. 3 and

Table 3

Distance of the lower level of colony of the limpet from the upper level
of the *Mytilus* zone.

Station No.	Minimum distance	Maximum distance	Difference
1	21 cm	21 cm	0
2	26 cm	46 cm	20 cm
3	41 cm	84 cm	43 cm

smallest in St. 1. Moreover, frequency of distance between them is also different according to Station, and it shows the largest value in St. 3.

IV GENERAL CONSIDERATION

According to the results mentioned above, it can be said that the levels of colonies of the limpet in 1954 are different from that in 1932. And the results became to the same state that tide level is retired downward in the east side of the island, namely in St. 1, but on the contrary, the tide level is uplifted in the west side of the island, namely in St. 3.

Then, why such a difference occurred? Here I can assumed that the rock of the island, Hadakajima, may be inclined in these 20 years, namely, the east side of the island is uplifted and the west side of the island sank. But another reason is also assumed that direction and velocity of wind are changed, and consequently physiological tide level is changed, and therefore the colonies of the limpet are formed on the different levels adapted to the changes of the tide level.

a) *Change of direction and velocity of wind.*

I have examined the velocity and direction of wind in every months in 1932, '33 and 1935 based upon the data taken by the Marine Biological Station, and compared with the data in 1952 and 1953, and found that both direction and velocity of wind are distinctly different from each other. Especially it seems to me that the direction and the velocity of wind in the months of March and April are most related with the formation of colony of the limpet, though the limpet begins to form a new colony at the end of March and completes by the middle of April.

The data of direction and velocity of wind in 1935 and 1952 are shown in Table 4.

In Table 4, it is clear that direction of wind is distinctly different between both years, namely, S W wind is the strongest in 1935, but West wind is the strongest in 1952.

Now comparing the data in Table 4 and the directions of the rocky shores in Fig. 1, it is easy to consider that waves sprush more vigorously in 1952 than in 1935 in St. 3. And the East wind is stronger in 1952 than in 1935, but the North-

Table 4
Comparison of velocity and direction of wind in the months of
March and April.

Direction Year	E	NE	N	NW	W	SW	S	SE
1935	34	4	3	155	198	227	5	0
1952	67	0	4	19	304	50	0	0

Numbers in the table shows the total velocity of wind in metres which is measured three time in a day.

west wind is distinctly weakened in 1952 than in 1935. Therefore, it may be considered that waves may sprush more gently in 1952 than in 1935.

Therefore it is considered that physiological tide level is more uplifted in 1952 in St. 3, but on the contraly, physiological tide level more descended in 1952 than in 1935 in St. 1. Consequently, the level of colony of the limpet is influenced by the variation of the physiological tide level and the results became as are shown in Tables 3 and 4.

b) *Change of zonation of inhabitants.*

As for inhabitants in the neighbourhood of the colony of the limpet, zonation of inhabitants in St. 1 was shown in Fig. 4 of the paper by Abe (1933), and zonation of inhabitants in St. 3 was shown in Table 2 in the paper by Abe (1940). In St. 1, number of *Mytilus crassitesta* increase and show *Mytilus* zone as is seen in Fig. 2 in the present paper, but on the contraly, *Septifer virgatus* (WIEGMANN) became very rare.

In St. 3, *Mytilus* zone is already seen as is shown in Table 2 (Abe, 1940), but number of individuals of *Mytilus* has increased moreover at the present time. In St. 2, inhabitants in 1931 are seen in Fig. 3 of the paper by Abe (1931) and also shown in Fig. 3 in Plate XII (Abe, 1931), and the *Mytilus* was seen only here and there, but *Mytilus* show excellent zone at the present time.

As mentioned above, the most prominent change of inhabitants is seen only in *Mytilus crassitesta*. As for other animals, *Thais (Mancinella) tumulosa clavigera* (KUSTER) and *Morula granulata* (DUCLOS) come to the level of the *Mytilus* for feeding on *Mytilus*, but they do not climb up to the level of the limpet, *Acmaea dorsuosa* GOULD. Therefore, it seems to me that such a change of zonation of the *Mytilus* do not show exact influence to the formation of colony of the limpet.

But I have observed that increase of number of barnacles, *Chthamalus challengerii* HOEK prevent the formation of colony of the limpet, and positions of colonies are gradually transferred, though such an example is seen in the neighbourhood of St. 1.

SUMMARY

Number of individuals and number of colonies of the limpet, *Acmaea dorsuosa* GOULD, in 1932 was compared with those in 1953 and 1954, and their changes during these 20 years were examined.

1. Number of colonies was increased and shows about 2.8 to 3 times over in 1954 than in 1932, while the number of individuals is increased only by about 14 to 18% during these 20 years.

2. Levels of the colonies of the limpet was lowered about 6 to 9 cms in St. 1, namely on the rocks facing eastward, but remarkable change is not seen in St. 2, namely on the rocks facing northward. But new colonies are formed on the level of 33 to 43 cm above the former levels in St. 3, namely on the rocks facing westward.

3. Distance of colonies from the upper level of *Mytilus crassitesta* zone is different according to Stations, namely the distance is the largest, showing from 41 cm to 84 cm, in St. 3 and it is smallest, showing 21 cm, in St. 1, though it shows from 26 cm to 46 cm in St. 2.

4. Direction of wind is distinctly different during these 20 years, namely S-W wind is the strongest one in 1935, but West wind is the strongest in 1952.

5. According to the variation of velocity and direction of wind, physiological tide level is more uplifted in 1952 than in 1932 in St. 3, namely on the rock facing westward, but on the contrary, physiological tide level more descended in 1952 than in 1935 in St. 1, namely on the rock facing eastward. Consequently, the level of colony of the limpet is influenced by the variation of the physiological tide level.

6. In the neighbourhood of the Marine Biological Station, number of individuals of *Mytilus crassitesta* increased more prominently in 1952 than in 1932, but such a change of zonation of *Mytilus* do not show exact influence on the colony formation of the limpet. But increase of number of barnacles prevent the colony formation of the limpet.

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A PRELIMINARY REPORT ON THE POISONOUS EFFECT OF THE *TOXOPNEUSTES* TOXIN UPON THE HEART OF OYSTER

By

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(With 11 Text-figures)

Most abalone-fishing divers have an intensive fear that the trumpet sea-urchin, *Toxopneustes pileolus* (LAMARCK), is poisonous and it is very dangerous to come in contact with their bodies. Nevertheless, no reports have been found, till to-day, concerning the biological research for so-called "*Toxopneustes* toxin", so far as we could know.

In the case of *Toxopneustes pileolus*, two kinds of modified pedicellariae, peculiar to this species, can be observed besides the ordinary pedicellariae, common in sea-urchins (Fig. 1). We will call the one "trumpet pedicellaria"; and the other "giant pedicellaria". The body surface of this species, when living, is covered by numerous trumpet pedicellariae, each of which spreading out among numerous spines and opening fully its trumpet-like tip with three fine hooks. A few giant pedicellariae of three-lobed large tip with similar hooks are mingled here and there among these trumpet ones. The white mucous fluid is ejaculated through these fine hooks, if the fully opened tips of these pedicellariae are stimulated by a sudden contact to close themselves vigorously. The vigorous closing reaction is exceedingly remarkable in the response of giant pedicellariae. Such a mucous fluid, from the giant and trumpet pedicellariae, is supposed to contain the above-mentioned toxic substance of this species or "*Toxopneustes* toxin".

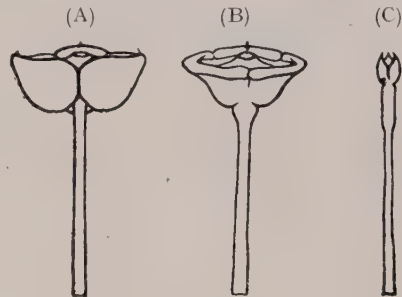


Fig. 1. Schematic representations, illustrating three kinds of pedicellariae of *Toxopneustes pileolus*. $\times 5$.

(A) giant pedicellaria, (B) trumpet pedicellaria, (C) ordinary pedicellaria.

In this paper, therefore, the writers will report the results of preliminary experiments, which were undertaken to investigate some physiological effects of so-called *Toxopneustes* toxin upon the rhythmic pulsation of the isolated heart from the shoe oyster, *Ostrea nippona* SEKI.

MATERIAL AND METHODS

Toxopneustes pileolus and *Ostrea nippona*, used for this study, were collected from the rocky bottom a little off the coast of Mugi-nachi, Tokushima Prefecture.

Through dissection, the oyster heart was carefully prepared, and then was suspended in the normal sea-water in a vessel of about 200 cc capacity. The pulsatory activities of the oyster heart were recorded by the kymographic method, experiments being made with or without the white mucous fluid containing the supposed *Toxopneustes* toxin. The following three different methods were employed to pour the mucus fluid into the oyster hearts.

(I) Direct Ejaculation from a Giant Pedicellaria

A fresh giant pedicellaria was separated from body surface of the sea-urchin by forceps and was kept in contact with the ventricle of oyster heart, prepared in the kymographic apparatus. If the separated pedicellaria was vigorous and undamaged, the hooks of this pedicellaria bit the heart wall actively, with a positive closing reaction of the tip caused by the contact stimulus. Simultaneously, the white mucous fluid was ejaculated from the giant pedicellaria directly into the ventricle of oyster heart.

(II) Injection with Mucous Fluid of Trumpet Pedicellariae

Many trumpet pedicellariae were separated from body surface of the sea-urchin by forceps and were treated with 0.5 mol KCl solution for several hours.

During this treatment, the white mucous fluid was plentifully yielded and deposited from these pedicellariae, probably due to some unknown stimulation by K-ion there. The deposited mucous fluid was pipetted quickly and bathed in the normal sea-water repeatedly. In such a manner, the mucous fluid could be collected indirectly from the treated pedicellariae and used for the injection into the oyster heart.

(III) Injection with "Corpuscles" and "Matrix" separated from Mucous Fluid.

By the microscopic observation, we could find the numerous particular corpuscles of fine dumb-bell shape and the surrounding matrix of milky viscosity

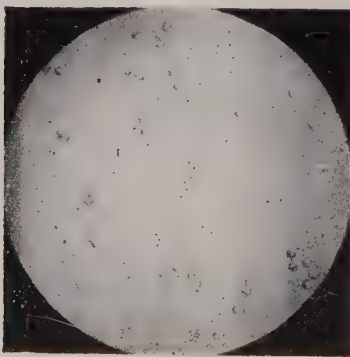


Fig. 2. Microphotograph showing "corpuscles" of mucous fluid, from trumpet pedicellariae. $\times 200$.

in the white mucous fluid, derived indirectly from trumpet pedicellariae (Fig. 2). These components of the mucous fluid, the corpuscles and the matrix, however, were separated into two different fractions by high centrifugal force. The one was the centrifugal fraction or corpuscles, and the other the centripetal fraction or matrix. Each fraction, therefore, could be independently injected into the oyster heart. Thus, the respective effect of "corpuscles" and of "matrix" upon the oyster heart was, also, investigated experimentally.

For the injection into the ventricle of oyster heart, a fine glass capillary or a minute syringe was utilized in the cases of *Experiments II* and *III*. As the control, the normal sea-water was injected into the ventricle of oyster heart in the same manner.

EXPERIMENTAL RESULTS

Experiment I. The pulsatory activities of oyster hearts, bitten by a giant pedicellaria, are all subjected to the inhibitory effects, but are somewhat different

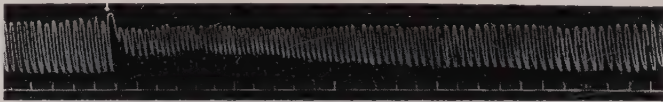


Fig. 3. Pulsation of oyster heart No. 1, showing inhibitory effect caused by a small quantity of mucous fluid in *Exp. I*.

Note: Time, marked per minute. Temperature, about 20°C.



Fig. 4. Pulsation of oyster heart No. 2, showing inhibitory effect caused by a large quantity of mucous fluid in *Exp. I*.

Time, marked per minute. Temperature, about 20°C.

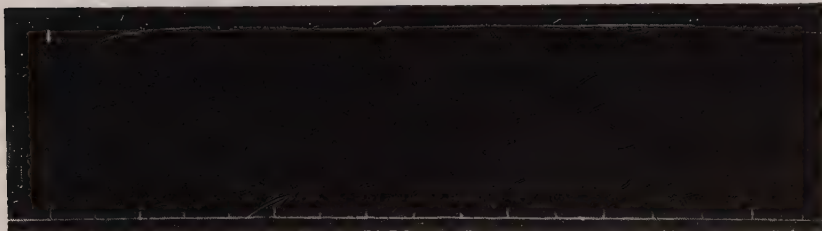


Fig. 5. Pulsation of oyster heart No. 3, showing complete inhibition caused by a larger quantity of mucous fluid in *Exp. I*.

Time, marked per minute. Temperature, about 29°C.

from one another in aspect, as are seen from Figs. 3, 4 and 5 respectively. In the case indicated by Fig. 3, the decayed giant pedicellaria is employed for supplying a little quantity of mucous fluid to the ventricle of oyster heart No. 1. Only a little inhibitory effect is recorded in this case. For several minutes immediately after ejaculation, the heart shows a little increasing tonus with faded amplitude, and soon recovers gradually to the original normal pulsation. In the case indicated by Fig. 4, the vigorous giant pedicellaria is employed for supplying much quantity of mucous fluid to the ventricle of oyster heart No. 2. A distinct inhibitory effect is produced on the pulsatory activities of the heart in this case. For several minutes immediately after ejaculation, the heart makes a sudden shortening with almost abolished pulsation. About twenty minutes later, the pulsatory power of heart begins to show a sign of recovering without the onset of initial shortening. About sixty minutes later or more, however, the pulsation cannot be recovered completely, although it shows a slightly decreasing tonus with gradually recovering amplitude. In the case indicated by Fig. 5, the most vigorous giant pedicellaria at higher temperature was employed for supplying a larger quantity of the mucous fluid to the ventricle of oyster heart No. 3. In this case, the pulsatory activities of oyster heart are affected with almost complete inhibition. The heart reacts into a clear-cut contracture at once, and abolishes its pulsation without any more recovering.

Experiment II. By the injection of white mucous fluid, derived indirectly from trumpet pedicellariae, the pulsatory activities of oyster hearts are, also, subjected to the inhibitions similar to those in *Exp. I*. These inhibitory effects are shown in Figs. 6, 7, 8 and 9 respectively. In the case indicated by Fig. 6, a little quantity of mucous fluid was injected by a fine glass capillary into the ventricle of oyster heart No. 4. For ten minutes immediately after the injection, the heart shows a slightly reduced pulsation with a little increased frequency and reduced amplitude, and soon begins to recover to the original pulsation. About twenty minutes later, the pulsatory power of oyster heart reaches the almost complete recovering. In the case indicated by Fig. 7, a small quantity of mucous fluid was injected through a fine glass capillary into the ventricle of oyster heart No. 5. For a few minutes immediately after the injection, the heart shortens rapidly and then shows an abnormally increased tonus with a gradual recovering to the normal pulsation. Thirty minutes later or more, however, the pulsatory activities are not yet completely recovered and remain to continue a slightly decreasing tonus with much reduced amplitude. In the case indicated by Fig. 8, much quantity of mucous fluid was injected by a minute syringe into the ventricle of oyster heart No. 6. A distinct inhibition appears on the pulsation of heart in this case. For a few minutes immediately after the injection, the heart reacts suddenly with the first increasing and then decreasing tonus. Several minutes

later, the heart begins to show again the rapidly increasing tonus with increased frequency and much reduced amplitude. About eighteen minutes later, moreover,

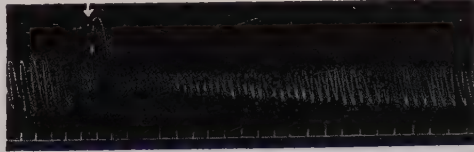


Fig. 6. Pulsation of oyster heart No. 4, showing inhibitory effect caused by a small quantity of mucous fluid in *Exp. II*.
Time, marked per minute. Temperature, about 20°C.

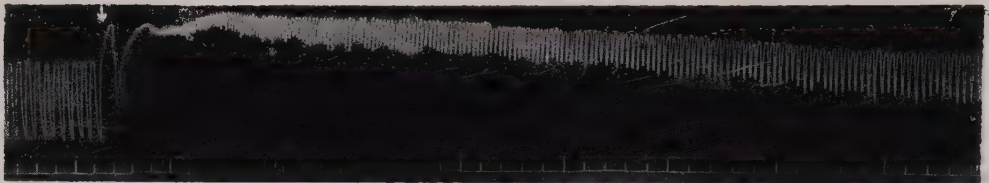


Fig. 7. Pulsation of oyster heart No. 5, showing inhibitory effect caused by a small quantity of mucous fluid in *Exp. II*.
Time, marked per minute. Temperature, about 20°C.

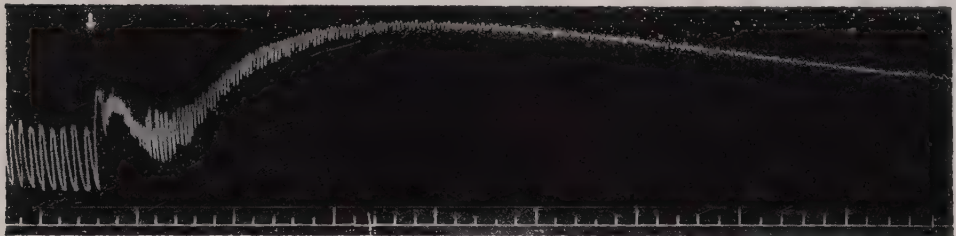


Fig. 8. Pulsation of oyster heart No. 6, showing inhibitory effect caused by a large quantity of mucous fluid in *Exp. II*.
Time, marked per minute. Temperature, about 20°C.

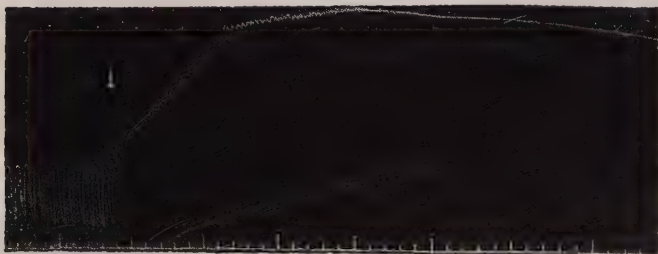


Fig. 9. Pulsation of oyster heart No. 7, showing complete inhibition caused by a larger quantity of mucous fluid in *Exp. II*.
Time, marked per minute. Temperature, about 20°C.

the tonus reaches the maximum and then decreases gradually with diminishing amplitude. About ninety minutes later, the heart abolishes the pulsation almost completely without any more recovering, tending to diastolic cessation. In the case indicated by Fig. 9, a larger quantity of the inucous fluid was injected by a minute syringe into the ventricle of oyster heart No. 7. The complete inhibition of the pulsation occurs at once in this case. As soon as the mucous fluid is injected into the ventricle, the heart shows a rapidly increased tonus, and diminished amplitude. About fifteen minutes later, the tonus reaches the maximum and its pulsation completely stops with gradual decrease of tonus in diastole.

Experiment III. Interesting results are obtained from the oyster hearts, injected with either fraction of the centrifuged mucous fluid. In the case indicated by Fig. 10, either centrifugal or centripetal fraction, densely suspended in sea-water, is injected alternately into the ventricle of oyster heart No. 8. In this case,

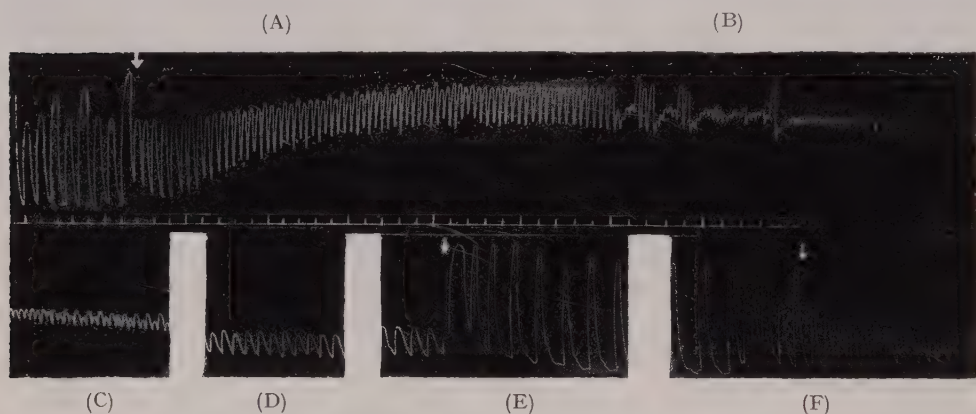


Fig. 10. Pulsation of oyster heart No. 8, showing effect of corpuscles and of matrix, separated from white mucous fluid.

Note: First injection, with corpuscles. Second injection, with matrix. Third injection, with corpuscles. Time, marked per minute. Temperature, about 20°C.

different effects occur on the pulsatory activities of oyster heart. For about twenty minutes immediately after the first injection with corpuscles, the heart shows the slightly increasing tonus with a little increased frequency and much reduced amplitude (Fig. 10 A). About thirty minutes later, the tonus reaches the maximum, when the previous feature of pulsation is interrupted repeatedly by abnormally diminished pulsations which go on thereafter (Fig. 10 B). About fifty minutes later, moreover, the heart decreases the tonus gradually (Fig. 10 C), and soon becomes stable in the diminished pulsation (Fig. 10 D). After that, the centripetal fraction or matrix was injected for the second time into the same ventricle. As soon as the second injection was given, the abnormally diminished

pulsation of oyster heart makes a sudden change and shows a greater amplitude than the original one, but is slowed down remarkably in its frequency (Fig. 10 E). Thirty minutes later, the corpuscle fraction was injected again into the same ventricle. The similar inhibitory effect of the corpuscles appears again and the heart suddenly diminished the pulsation with increased frequency and much diminished amplitude (Fig. 10 F).

GENERAL CONSIDERATIONS

In all experiments stated above, the oyster hearts may have been subjected to the possible inhibitory effect of the mechanical stimulus caused by the hooks of giant pedicellaria and by the glass capillary or needle of the syringe, in addition to the chemical stimulus of white mucous fluid under investigation. The inhibitory effect of the mechanical stimulus is here open to question. As the control to

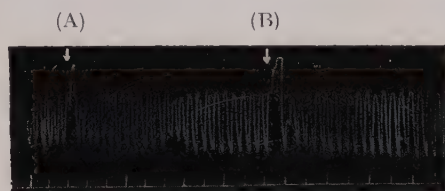


Fig. 11. Pulsation of oyster heart No. 9, showing two abnormal contractions caused by mechanical stimuli of injections. Time, marked per minute. Temperature, about 20°C.

make clear this question, a small quantity of normal sea-water was injected repeatedly by a minute syringe into the ventricle of oyster heart No. 9.

At the first injection, the oyster heart reacts instantly with an abnormally increased contraction following the mechanical stimulation of injection, as shown in Fig. 11 A. The pulsatory power of oyster heart, however, recovers completely to the normal pulsation within a few minutes. At the second injection, a similar abnormal contraction also occurs on the pulsation of oyster heart, which shows the prompt recovering to the original rhythm (Fig. 11 B). As the results of this experiment, it is found that the mechanical stimulus just investigated causes only a temporarily increased contraction in the pulsation of oyster heart. Accordingly, the various inhibitions of the pulsatory activities of oyster heart mentioned above may safely be considered to be due to some toxic substances contained in the white mucous fluid.

On the other hand, it is doubtful that the inhibitory effect of poisonous corpuscles is quite different from that of poisonous matrix. A certain remarkable correlation like synergism or antagonism seems to be suggested in both poisonous effects between these different components of white mucous fluid. In order to

make clear this point, the research will be continued further from both physiological and chemical points of view. In conclusion, it has been confirmed by the present experiments that some remarkable poisonous effects upon the oyster heart are caused by the white mucous fluid secreted from the giant and trumpet pedicellariae of *Toxopneustes pileolus*.

SUMMARY

(1) In the present paper, the writers have reported the results of the experiments, which were undertaken to investigate the so-called poisonous effect of *Toxopneustes pileolus* upon the heart pulsation of *Ostrea nippona*.

(2) In different experiments, the prepared hearts of oysters for the kymographic apparatus have been injected directly or indirectly with the white mucous fluid, which was obtained from the "giant" and "trumpet" pedicellariae peculiar to this sea-urchin (Fig. 1).

(3) The conspicuous inhibitions of the pulsations of oyster hearts, shown in Figs. 3—9, may be assumed to be chiefly due to the poisonous effect of the white mucous fluid. The mechanical stimulus, due to the experimental procedure, affects the oyster heart causing only a temporary disturbance of pulsation as shown in Fig. 11.

(4) The white mucous fluid is composed of both poisonous corpuscles (Fig. 2) and poisonous matrix, which can be separated by high centrifugal force into two different fractions. The inhibitory effect of poisonous corpuscles is quite different from that of poisonous matrix, as shown in Fig. 10.

(5) In conclusion, the presence of so-called *Toxopneustes* toxin, complicatedly poisonous to the pulsatory activities of oyster heart, was confirmed experimentally in the white mucous fluid, secreted from the tips of giant and trumpet pedicellariae of *Toxopneustes pileolus*.

THE EFFECTS OF LITHIUM CHLORIDE ON HEAD-FREQUENCY
IN *DUGESIA GONOCEPHALA* (DUGÈS)

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(With 2 Figures and 3 Tables)

The influences of various reagents on head-frequency in regenerating pieces of planaria have been tested by many authorities.

Child (1911 b) found that the regenerates gave rise to a small head or sometimes to a cyclopia after treating pieces of *Planaria dorotocephala* with alcohol and ether. Buchanan (1923) observed the change of head-frequency by treatment of pieces of *Planaria dorotocephala* with chloretone, chloroform, chloral hydrate, ether or ethyl alcohol. Rustia (1925) reported that the frequency of biaxial head formation is increased by treating short pieces of *Planaria lata* with HCl, ether or chloretone.

According to Brøndsted (1942), on the other hand, lithium chloride has no effect on the head-frequency in *Planaria lugubris*, but it is effective for the formation of supplementary eyes. These results show that the effect of reagents is different in different species and conditions of experiments.

It is well known that the action of lithium chloride is characteristic in the morphogenesis of the sea-urchin and the amphibian eggs. In the present experiment the writer tested the effect of lithium chloride on the head-frequency of the *Dugesia gonocephala*.

The writer wishes to express his sincere thanks to Dr. I. Motomura, Professor of the Tohoku University, for his supervision during the course of this work.

MATERIAL AND METHOD

The material used was the asexual form of *Dugesia gonocephala* which was collected from the streams in Sendai, late in August of 1948. The size of individuals ranges from 14 to 18 mm. in length. Before the experiment they were kept fasting at least for a week.

In the experiments three types of operation were performed. The worms

were first decapitated at the level of postcephalic base, and then, the remaining part was cut into four pieces by cutting at the levels of pharyngeal base, mouth, and at the middle of the postpharyngeal region. Other two types are cutting in equal lengths of pieces of decapitated animals into seven or fifteen. The pieces were cultured at room temperature in Petri-dishes containing boiled tap water.

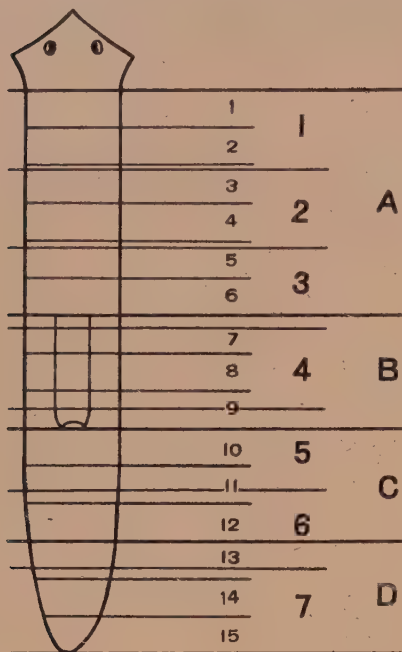


Fig. 1.

RESULTS

Normal head-frequency

The experiments of four or seven cuts showed the same tendency of the head-frequency on the eighth day after the cutting. The rate of head regeneration decreases from the anterior to posterior, except the posterior portion of the pharynx, where the rate increases and then decreases posteriorly again (Fig. 2). On the 18th day after the cutting, the rate was nearly equal in each level as the head was regenerated in more than 83 per cent of the

pieces. No individual of reversed polarity was observable throughout those experiments. On the contrary, in the experiments of 15 cuts, a few specimens with regenerated heads on both anterior and posterior sides, biaxial heads, were observed in the pieces from the levels of 5th to 13th, and especially from its middle part of the body (Table 1). Those experiments show that it is suitable to use the four cuts or seven cuts for the experiment of the head-frequency in this species.

Regeneration in lithium treated pieces

In the experiments of lithium treatment only the method of four cuts was used. The pieces were treated with 0.5 per cent LiCl for 1.5, 3, or 5 minutes, and then observed on the fifth and seventh day after cutting. The regeneration proceeded gradually to form the normal head in those days; that is, the regenerating heads were mainly in the stages of the formation of one or two eye spots or anophthalmia on 5th day, while on the seventh day the normal outline of the head was formed in one-third or the pieces (Table 2). The regeneration was inhibited by treatment with lithium chloride in comparison with control (Table 2). The

tendency of the head frequency in the lithium-treated pieces was nearly the same as the control, but the rate of head regeneration was strongly inhibited in the

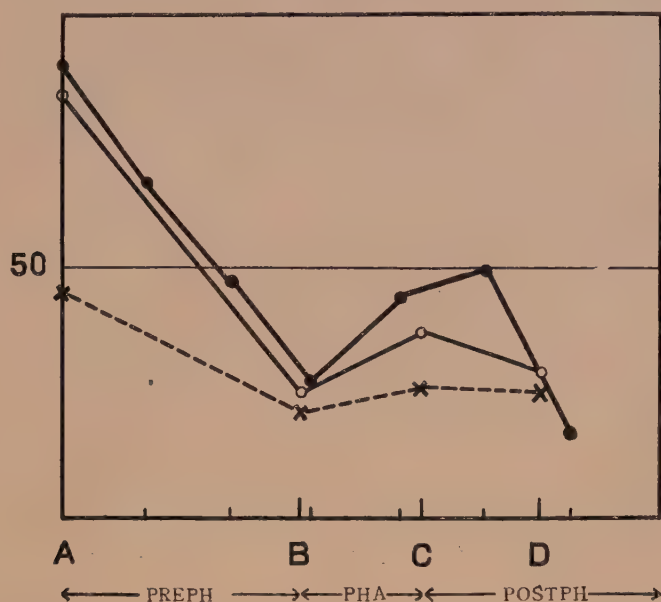


Fig. 2. The head-frequency of normal and Li-treated pieces of *Dugesia gonocephala* observed on the ninth day after cutting: White circles, cutting into four parts; solid circles, into seven parts; cross and dotted line, Li-treated (3minute) pieces. Ordinate, percentage of regeneration of normal head: PREPH, prepharyngeal region; PHA, pharyngeal region; POSTPH, postpharyngeal region.

Table 1

The biaxial head-frequency in one-fifteenth pieces.

region of body		anterior half of prepharyngeal region			posterior half of prepharyngeal region			pharyngeal region			anterior half of postpharyngeal region			posterior half of postpharyngeal region		
level of pieces		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of pieces	alive	11	9	9	10	8	9	12	6	8	10	7	9	10	12	14
	died	4	6	6	5	7	6	3	9	7	5	8	6	5	3	1
	normal head	11	9	9	10	6	7	9	5	5	7	6	9	9	12	14
	biaxial head	0	0	0	0	2	2	3	1	3	3	1	0	1	0	0
		0			4			7			4			1		

The levels of pieces are shown in Fig. 1.

regions of high head-frequency in control, that is, pieces A, and C.

As mentioned above, the biaxial head was formed in the pieces of pharyngeal region and its neighborhood of the one-fifteenth cut experiments, while it was

never the case in longer pieces, such as four cuts or seven cuts. In the experiments of lithium treatment the biaxial head was formed in longer pieces of four cuts,

Table 2

Type and frequency of regenerated head observed on the fifth and seventh day after the treatment with lithium chloride.

Time of observation	treatment with LiCl	normal head	subnormal head	teratophthalmia	no transparent area	2- small eye spots	1-side eye	anophthalmia	acephalia	died	total
5th day	Cont.	0	2	4	98	192	31	73	0	0	400
	1.5 Min	0	0	1	36	198	30	132	1	2	400
	3.0 Min	0	0	0	20	178	38	161	1	2	400
	5.0 Min	0	0	0	16	172	30	157	3	22	400
7th day	Cont.	9	94	42	187	16	28	14	0	10	400
	1.5 Min	5	67	69	166	33	25	22	0	13	400
	3.0 Min	3	73	61	165	32	35	18	0	13	400
	5.0 Min	0	63	47	147	49	29	31	1	33	400

Table 3

The biaxial head, reversed head and biaxial tail-frequency in the treatment of the worm with lithium chloride.

Treatment with LiCl	Type of regenerate Level of pieces	2 eyes on ant. and post.	2 eyes on ant. and 1 eye on post.	1 eye on ant. and post.	2 eyes on post. only	1 eye on post only	Tail on ant. and post.	Total
1.5 Min	A		2					2
	B		3					3
	C	6	4	3			1	14
	D							0
3.0 Min	A			1	1			2
	B					1		1
	C		5	3				8
	D							0
5.0 Min	A		3					3
	B		1					1
	C		4	1				5
	D							0

and even in the pieces from prepharyngeal (A), pharyngeal (B), and anterior postpharyngeal (C) regions (Table 3). Three types of biaxial head regeneration were observed; they are, two eyes in each head, two eyes in anterior regenerate and one in posterior, and one in each head. Besides those the head regeneration in reverse direction, and biaxial tail regeneration were also observed. These results show that by the lithium treatment the direction of the craniocaudal axis

of the regenerating pieces was reversed even in relatively long pieces of *D. gonocephala*.

DISCUSSION

In the present experiment the head-frequency showed the tendency to form two peaks, in anterior end and postpharyngeal regions. In *P. dorotocephala* and *P. maculata*, it has been reported that the frequency is high at anterior and posterior end of the worm (Child, 1911 a). In *D. gonocephala* and *E. dorotocephala* on the other hand, Watanabe (1941, 1935) reported the presence of two peaks as observed by present writer. The tendency of head frequency is, therefore, different according to the species used.

The biaxial head formation has been observed by Morgan (1904), Child (1911 a), and Okada and Sugino (1937) in small pieces of *P. maculata*, *P. dorotocephala* and *D. gonocephala* respectively. As mentioned above the biaxial head was formed in pieces of pharyngeal region in one-fifteenth cut experiment. The writer's results agree with the regeneration of small pieces in tap water. phenomenon is accelerated in lithium treated pieces of larger size.

Brøndsted (1942) observed the influence of lithium on the regeneration of *P. lugubris* and drew the conclusion that this chemical is toxic, lowering the respiration, but has no effect on the head-frequency. The last mentioned fact contradicts the writer's results. The writer has published a preliminary report on the biaxial head formation in lithium treated pieces of *D. gonocephala* (Teshirogi, 1951). And, recently Mifune (1953) also has reported the polycephalia and heteropolar heads even when in the regeneration of long pieces of the same species by the successive treatment with LiCl and low temperature. The writer has the opinion that the biaxial head regeneration in lithium treated pieces is rather easy in *D. gonocephala*.

SUMMARY

The effects of lithium chloride on the regeneration and head-frequency in *Dugesia gonocephala* were tested. The regeneration was inhibited by treatment with lithium chloride. The biaxial head, reversed head and biaxial tail were formed in relatively long pieces after the treatment with lithium chloride. The regeneration of those types was observed frequently in the pieces from the middle regions of the worms.

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STAINING EMBRYOS OF *SARGASSUM CONFUSUM* AG.,
A BROWN ALGA.*)

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(With 1 Figure and 3 Tables)

According to Gellhorn (1927), the grade of vital staining in the eggs of some marine animals begins to increase after fertilization. The same phenomenon was introduced by the writer (1953a) in some Fucaceous algae with a remark that the staining appears in the higher degree in the basal part, the lowest in the apical, and there is a gradient between the two. This increase of staining was explained with an idea of increasing permeability to the dyes after fertilization, and the polar staining from the permeability gradient along the major axis of the egg. A question is raised herein as to whether or not this differential stainability is maintained till the embryo stage, and moreover, whether or not the characteristic staining does appear also in the fixed material as was reported by Drawert (1938) in *Helodea* leaf. The present paper is a report of some experiments on this problem.

For the material, *Sargassum confusum* Ag. was collected from a beach near the Marine Biological Station at Asamushi on May 25th, 1952. Eggs discharged in glass jars were scraped off with a glass needle from the surface of the receptacle, artificially fertilized, and then cultured in Petri dishes with normal sea-water. Three days later, majority of these eggs developed to young embryos forming eight rhizoid primordia, and on the next day the primordia grew longer up to eight rhizoids. This was the normal course of development. The embryos thus developed were stained vitally and after being fixed with 10 per cent formalin at two different stages: 1) the rhizoid primordia stage (Fig. 1a) and 2) the rhizoid growing stage (Fig. 1b). For the staining, 1 per cent water solutions of twelve dyes were prepared at first. The solutions were separately diluted into sea-water of pH 8.2 for the vital staining or into distilled water for staining the fixed embryos in the proportion of 1 drop of a solution to 10 cc of sea- or distilled water. The staining media thus prepared were put in Petri dishes, in which the embryos were

* Contributions from the Marine Biological Station of Asamushi, No. 215.

stained. All the procedure was carried out at the room temperature, about 12°C.

1. Vital staining.

The embryos were sucked up from the staining media with a pipette about five hours later than the time when they were soaked, placed on the slide glass and observed. The result of it is presented in Table 1. According to the table,

Table 1
Vital staining of the embryos of *Sargassum confusum* Ag.

Dyes	Rhizoid primordial stage		Rhizoid growing stage	
	Apical part	Basal part	Apical part	Basal part
Anilin blue	—	—	+	—
Aurantia	—	—	—	—
Bismarck brown	+	+	+	—
Brilliant green	—	+	—	+
Congo red	—	+	+	+
Janus green	—	—	—	—
Methylene blue	—	+	+	+
Neutral red	—	+	—	+
Nile blue	—	—	—	+
Safranin	—	+	—	+
Thionin	—	—	—	—
Toluidin blue	+	+	—	—
Control	—	—	—	—

it is clear that the basal (rhizoidal) portion is more stainable than the other part of the embryo. This is in accordance with the writer's previous investigations (1953a) on the earlier stage of the same species. In this case, as is seen from that the dyes effective for the polar staining were all basic, the characteristic staining

is related to the nature of those dyes whether they are acidic or basic, the latter being the more permeant. The polar staining, which appeared at first in the rhizoidal part (Fig. 1a, b), gradually spreads in time till the whole body stains without differentiation. The embryos, thus being stained, were able to live for a day or two with continuous occurrence of the cell division. The polar staining, therefore, does not seem to be caused by the partial decolorization, but seems to be attributed to the partial difference of permeability, which is the highest in the rhizoidal part.

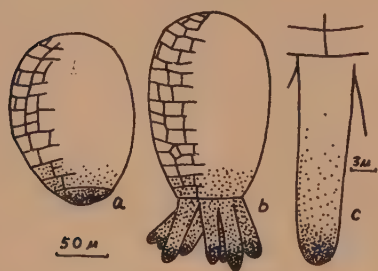


Fig. 1. Staining embryos with brilliant green, *Sargassum confusum* Ag. a) Rhizoid primordial stage, b) rhizoid growing stage, stained vitally. c) Polar staining at the tip of the fixed rhizoidal cells.

A notable staining was observed with methylene blue. That is, in this case

the stainability is restricted to a certain kind of individuals. And the remainder does not stain evenly or differentially. Thus the ratio between the two types of embryos, stainable and nonstainable, was calculated as 1 : 1. The writer is of the opinion that this may suggest the sexual difference among the embryos, considering the similar phenomenon which was reported by Joyet-Lavergne (1927) in horse-tail spores. It is also remarkable that while Bismarck brown stains differentially in the rhizoid growing stage, the differential staining does not appear in the primordial stage. This is attributed to the fact that those which stain with this dye are the microsome-like particles which are distributed all over the plasm of the embryo in the primordial stage as well as in the egg stage, while the particles are degenerated later on in the rhizoid cell. If the embryos are left longer in this dye solution, however, the plasm itself begins to stain, and as a result the rhizoid cells as well as the apical cells stain brown.

2. Staining the fixed embryos.

According to Drawert (1938), *Helodea* leaf, even after being fixed with 70 per cent alcohol, does not lose its permeability differentiation for some dyes or various chemicals. The same phenomenon was observed in fern prothallia by Reuter (1953). Herein, the present writer made some experiments on the fixed material. For this purpose, the embryos, fixed with 10 per cent formalin, washed with distilled water, were stained likewise as in the former experiment. The time for the staining, however, was much shortened to an hour or so owing to the previous knowledge that the dead embryos are generally much more stainable. The result is shown in Table 2.

Table 2
Staining of the fixed embryos of *Sargassum confusum* Ag.

Dyes	Rhizoid primordial stage		Rhizoid growing stage	
	Apical part	Basal part	Apical part	Basal part
Anilin blue	+	+	+	+
Aurantia	—	+	—	+
Bismarck brown	+	+	—	—
Brilliant green	—	+	—	+
Congo red	+	+	+	+
Janus green	—	—	—	—
Methylene blue	—	—	—	—
Neutral red	—	+	—	+
Nile blue	—	—	—	—
Safranin	+	+	—	+
Thionin	+	+	+	+
Toluidin blue	—	+	—	+
Control	—	—	—	—

What is notable in the fixed embryos was the partial or general new acquisition of stainability with anilin blue, aurantia, Congo red, safranin, thionin, and toluidin blue, while on the other hand the loss of stainability with methylene blue ac-

accompanied. The new acquisition of the stainability is not in connection with acidic or basic property of the dyes. In spite of the change of the stainability

Table 3
Polar staining within the single rhizoidal cell of the fixed embryos,
Sargassum confusum Ag.

Dyes	Rhizoid joint	Rhizoid tip
Anilin blue	—	+
Aurantia	+	++
Bismarck brown	—	—
Brilliant green	—	++
Congo red	+	+
Janus green	—	—
Methylene blue	—	—
Neutral red	+	++
Nile blue	—	+
Safranin	+	++
Thionin	+	+
Toluidin blue	—	+
Control	—	—

which resulted from the fixation like this, the characteristic polarity which appeared in the vital staining has been retained with brilliant green, neutral red, and safranin. In addition, a new polarity has been acquired with aurantia and toluidin blue. Thus the permeability differentiation is able to be kept unchanged or newly brought about through the fixing.

The polarity of stainability was also observed within the single rhizoid cell of the fixed embryos as is presented in Table 3. A remarkable staining was discovered in anilin blue. That is, the embryo as a whole stains with this dye in the same degree both in the apical and the basal regions as is seen in Table 2, while within the single rhizoid cell, the staining appears more striking in the tip and less so at the joint where the rhizoid is connected to the main part of the embryo. Among the eight dyes with which the rhizoids were stained, only two, Congo red and thionin, failed in the polar staining. And the remainder were all able to stain more deeply in the tip zone within the cell (fig. 1c). The differentiation, however, gradually diminishes with the lapse of time till the whole cell stains evenly.

From the above experiments, in consideration with the preceding reports (1953a, b), it is seen that the permeability gradient which appeared just after fertilization has been succeeded in the same direction through the course of development at least till the embryo stage. Besides, it is retained even if the embryos are fixed with formalin. This is in accordance with results in *Helodea* (Drawert 1938) and fern prothallia (Reuter 1953). The staining polarity, however, appeared a little different from what was reported by Reuter. That is, in the fresh or the fixed embryos of the present alga, the stainable part is not of the young cells capable of division of which the main part of the embryo consists,

but of the basal cells which do not divide but grow, and older than the former. Hence, the abilities of growth and cell division seem to be different properties as far as the staining reveals. The permeability to the dyes is the least in the apical pole, increasing gradually towards the rhizoid, within which it is the highest at the tip. The present writer is rather of the same opinion as Prát (1931a, b, 1932) and Weber (1932) who consider that the permeability to some dyes are the highest in the growth point. This interpretation may also be applied to the similar phenomenon which appeared in the shoot tip of various marine algae (Nakazawa 1953c).

SUMMARY

The embryos of *Sargassum confusum* Ag. were stained with various dyes vitally or after fixation with formalin. As a result, it was known that 1) generally the basal (rhizoidal) part is more stainable than the apical part, 2) the polar staining is attributed to the polar differential permeability, and 3) it is the succession in the same direction from the earlier stage.

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OCEANOGRAPHICAL OBSERVATIONS OFF ASAMUSHI
DURING 1953*)

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(With 4 Figures and 1 Table)

INTRODUCTION

This article is a report on the oceanographical observations carried out at a definite station as the routine work during January to December, 1953.

The method of observation was the same as that in the investigations of preceding years. As shown in Table 1, nineteen series of observations were made in this year.

The writer wishes to express his hearty gratitude to Prof. Dr. S. Nomura, Director of the Marine Biological Station of Asamushi, Tōhoku University, for constant guidance in the course of the work.

RESULTS

1) *Water Temperature*

The conditions of water temperature in 1953 are shown in Fig. 1.

The minimum water temperature was observed during from the middle of February to the middle of March. At the surface, the cold water below 6°C occurred in the same season and the value of 5.39°C which was the lowest temperature in 1953, was observed on February 17. Thereafter the water temperature gradually rose in each layer and approached the maximum. The maximum temperature appeared at the surface early in August, that at the 10 m depth in the middle of August, and that at the 30 m depth in the middle of September in this year. It was noticed that the maximum at the surface appeared early in August, while it usually occurs in the middle or in late August. The curve of temperature seems rather not to differ much in October, November and December compared with the preceding year.

Considering the annual change of vertical distribution of water temperature in 1953, the direct stratification, which seems to be rather uncommon in the winter

* Contributions from the Marine Biological Station of Asamushi, No. 216.

season, was observed on January 5. After this the inverse stratification occurred twice a year during from late January to the middle of March, and from early September to the middle of December. Meanwhile, the period of direct stratification was between the middle of May and the middle of August. Taking

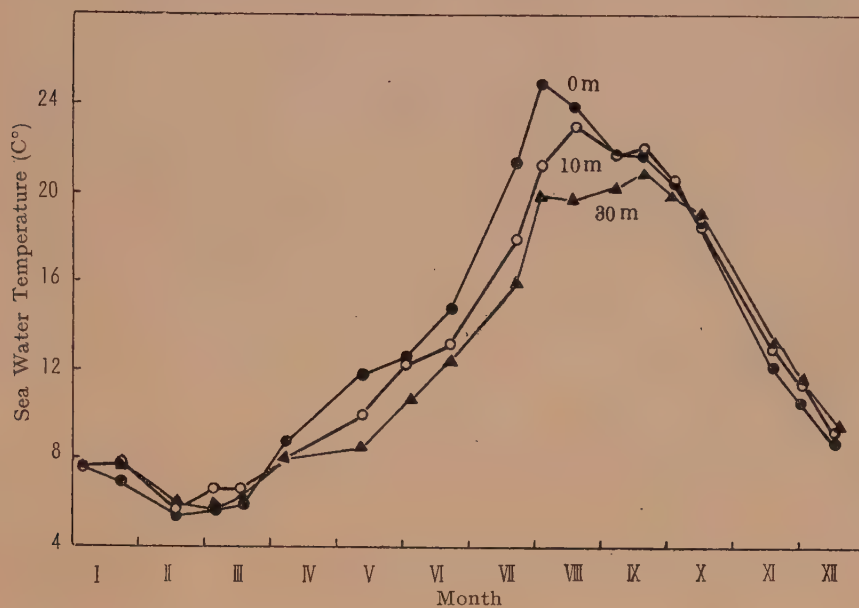


Fig. 1. Annual change of Sea water temperature at different depths during 1953.

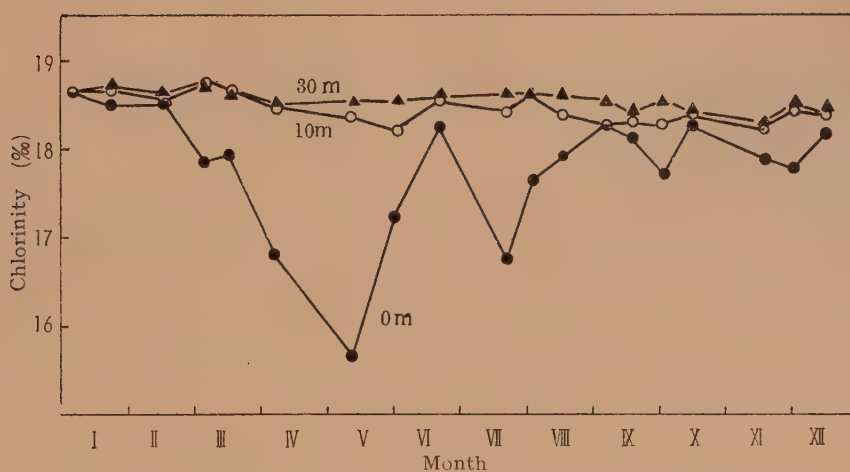


Fig. 2. Annual change of chlorinity at different depths during 1953.

Table 1
Oceanographical conditions observed at definite

No. of Observations	Date	Water Temperature (°C)					Chlorinity (‰)					Oxy-	
		0	5	10	20	30	0	5	10	20	30	0	5
1	Jan. -5	7.64	7.64	7.61	7.61	7.59	18.65	18.64	18.64	18.64	18.64	6.53	6.48
2	Jan. -22	6.91	7.55	7.79	7.94	7.92	18.50	18.62	18.67	18.69	18.69	6.70	6.61
3	Feb. -17	5.39	5.52	5.69	6.05	6.05	18.50	18.52	18.54	18.62	18.63	7.19	7.05
4	Mar. -5	5.60	6.47	6.62	6.66	5.83	17.86	18.64	18.74	18.74	18.76	7.30	7.20
5	Mar. -17	5.91	6.62	6.62	6.61	6.57	17.94	18.64	18.65	18.66	18.67	7.22	7.17
6	Apr. -7	8.69	8.28	8.00	8.02	8.12	16.80	18.20	18.46	18.49	18.49	6.93	6.94
7	May -11	11.82	10.28	9.94	8.89	8.41	15.67	18.28	18.36	18.51	18.55	6.71	6.71
8	June -1	12.64	12.41	12.32	11.94	10.46	17.23	18.20	18.21	18.48	18.54	6.30	6.28
9	June -21	14.76	13.75	13.24	12.66	12.52	18.24	18.54	18.54	18.61	18.61	6.04	6.32
10	July -21	21.29	18.80	17.87	16.86	15.94	16.76	18.40	18.41	18.41	18.61	5.97	5.73
11	Aug. -2	24.91	22.29	21.27	20.88	19.88	17.66	18.51	18.58	18.58	18.62	5.17	5.50
12	Aug. -17	23.93	22.99	23.01	21.08	19.76	17.91	18.39	18.38	18.50	18.61		
13	Sept. -6	21.76	21.80	21.79	21.70	20.22	18.25	18.25	18.26	18.25	18.55	5.25	5.26
14	Sept. -18	21.72	21.82	22.00	21.86	20.98	18.13	18.17	18.28	18.31	18.41	5.63	5.08
15	Oct. -2	20.42	20.47	20.64	20.69	19.49	17.69	17.69	18.27	18.30	18.52	5.50	5.29
16	Oct. -15	18.54	18.82	18.49	18.88	18.98	18.26	18.32	18.37	18.41	18.42	5.39	5.32
17	Nov. -18	12.20	12.45	13.05	13.35	13.38	17.87	18.06	18.22	18.29	18.29	5.96	5.85
18	Dec. -1	10.59	11.27	11.40	11.55	11.60	17.77	18.32	18.40	18.43	18.47	6.19	6.03
19	Dec. -16	8.80	8.82	9.31	9.43	9.43	18.16	18.18	18.38	18.42	18.42	6.46	6.42

this point into consideration, 1953 seems rather to be a normal year.

2) Chlorinity

The seasonal changes of chlorinity in 1953 are shown in Fig. 2.

The quantity of chlorinity at 10 m and 30 m depths was less variable throughout the year, fluctuating between 18.22 ‰ and 18.67 ‰ at 10 m depth, between 18.29 ‰ and 18.69 ‰ at 30 m depth. The chlorinity of surface showed almost the same value (18.65 ‰) with that of 10 m and 30 m depth at January 5. Since the early March, it gradually decreased and attained the lowest value of this year in the middle of May.

From 1950 until the present study, the value below 16.00 ‰ observed, is tabulated as follows.

Year	Date	Chlorinity
1950	Apr. 16	14.66 ‰
	May 2	15.85
1951	Apr. 6	15.94
1952	Apr. 8	14.59

Station off Asamushi during 1953.

gen (cc/L)			Saturation of O ₂ , %					pH					Colour of Water	Transparency
10	20	30	0	5	10	20	30	0	5	10	20	30		
6.50	6.52	6.60	96.3	95.5	95.8	96.0	96.9	8.4	8.4	8.4	8.4	8.4	4	12
6.72	6.60	6.39	97.1	97.3	99.5	98.0	94.5	8.4	8.4	8.4	8.4	8.4	5	10
7.03	6.91	6.92	100.2	99.0	99.0	98.5	98.4	/	/	/	/	/	5	9
7.19	7.12	7.13	102.0	103.4	103.4	102.6	103.0	/	/	/	/	/	5	/
7.20	7.12	7.13	101.4	103.2	103.6	102.2	102.2	/	/	/	/	/	5	8
6.97	6.98	6.96	101.4	102.6	103.0	103.0	103.0	8.4	8.4	8.4	8.4	8.4	5	10
6.80	6.63	5.60	104.0	104.1	104.4	100.0	83.9	/	/	/	/	/	6	6.5
6.70	6.56	6.30	106.0	106.0	107.4	105.0	98.0	/	/	/	/	/	4	13
6.42	6.50	6.42	101.6	105.0	105.8	105.0	104.4	/	/	/	/	/	4	11
5.90	5.77	5.08	109.6	103.0	104.8	100.4	88.0	8.4	8.4	8.4	8.3	8.3	5	9.5
5.48	5.42	5.10	102.8	107.8	103.8	102.0	96.0	8.4	8.4	8.4	8.4	8.4	4	9
/	/	/	/	/	/	/	/	8.4	8.4	8.4	8.4	8.4	5	8
5.41	5.36	5.06	99.8	100.0	103.0	101.4	94.0	8.4	8.4	8.4	8.4	8.4	5	9
5.40	5.05	4.66	100.4	96.5	102.6	96.2	87.2	8.4	8.4	8.4	8.4	8.4	4	10
5.13	5.00	4.39	101.0	98.0	96.0	93.6	80.5	8.4	8.4	8.4	8.4	8.4	6	7
5.31	5.22	5.28	97.0	96.3	96.0	94.6	95.5	8.4	8.4	8.4	8.4	8.4	6	10
5.76	5.25	5.30	95.0	94.0	93.9	85.9	87.0	8.4	8.3	8.4	8.4	8.5	6	6
5.98	6.00	5.98	95.8	95.2	94.3	95.2	95.2	8.5	8.5	8.5	8.5	8.4	4	11
6.40	6.29	6.38	97.0	97.0	97.0	95.5	97.0	8.4	8.4	8.4	8.5	8.5	4	12

May 5 14.67
 1953 May 11 15.67

As was seen in the above table, the lowest value of chlorinity has been observed during from April to May in each year. It is thought that the low chlorinity of surface layer in the spring season, must be caused by the thaw water, as reported in this series. Thereafter the chlorinity of surface mounted to 18.25 ‰ on June 21, increased gradually, but there was again a low value on July 21, showing 16.76 ‰. The decrease of chlorinity can be accounted for by the increased inflow of inland water into Mutsu Bay, for the period from June to July has been the rainy season in every year. After this season to December, the chlorinity of surface increased, and no such decrease as in May and July was observed in this year.

As regards the annual change of vertical distribution, it was seen that the chlorinity showed the lowest value at the surface in every month, and increased with the depth.

3) Dissolved Oxygen

The curves of annual change of dissolved oxygen in 1953, (Fig. 3) did not differ much from that in 1952.

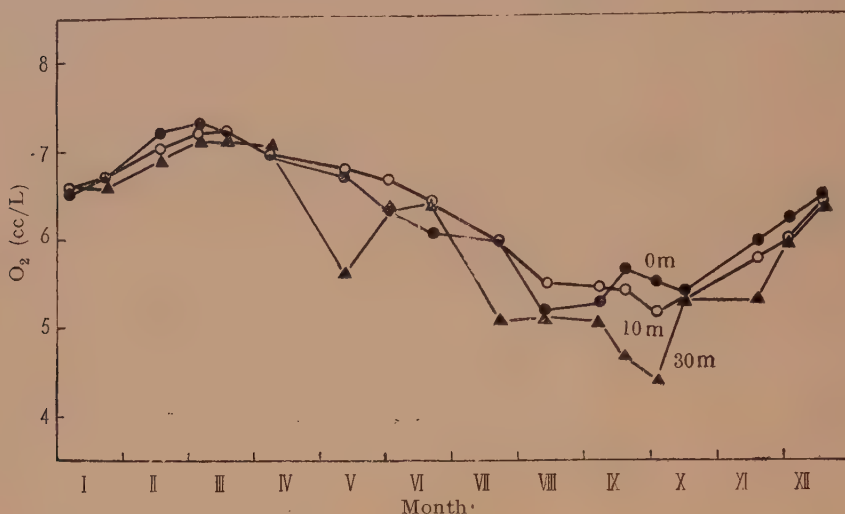


Fig. 3. Annual change of the O_2 content of sea water at different depths during 1953.

In 1953, the maximum oxygen content in each layer was observed in March, but the minimum values occurred at the surface in August, at 5 m depth in September, and below 10 m depth in October.

Referring to the data in 1952, the extreme values have been as follows:—

Year	Highest value			Lowest value		
	O_2 , cc/l	Depth	Date	O_2 , cc/l	Depth	Date
1952	7.36	0 & 5 m	Mar. 18	4.26	30 m	Sept. 15
1953	7.30	0 m	Mar. 5	4.39	30 m	Oct. 2

From the above table, it is noted that the highest value appeared in the spring season, showing about 7.3 cc/l at the surface layer, and that the minimum value in the autumn season, showing about 4.3 cc/l at the bottom layer.

As regards the vertical distribution, oxygen content in each month showed the highest value in the surface throughout the year and the lowest value in 30 m depth, except some observations. But it can be seen from Fig. 3 that oxygen content at 10 m depth was rather larger than that at the surface in April, May, June, August and September, owing to the photosynthesis of phyto-plankton.

The seasonal change of the percentage saturation in this year (Fig. 4) indicated that it varied between 109.6% and 96% at the surface, between 107.4% and 93.9% at 10 m depth, and between 104.4% and 80.5% at 30 m depth, and that at 30 m

depth it was more variable than in other layers, as was seen in the preceding years.

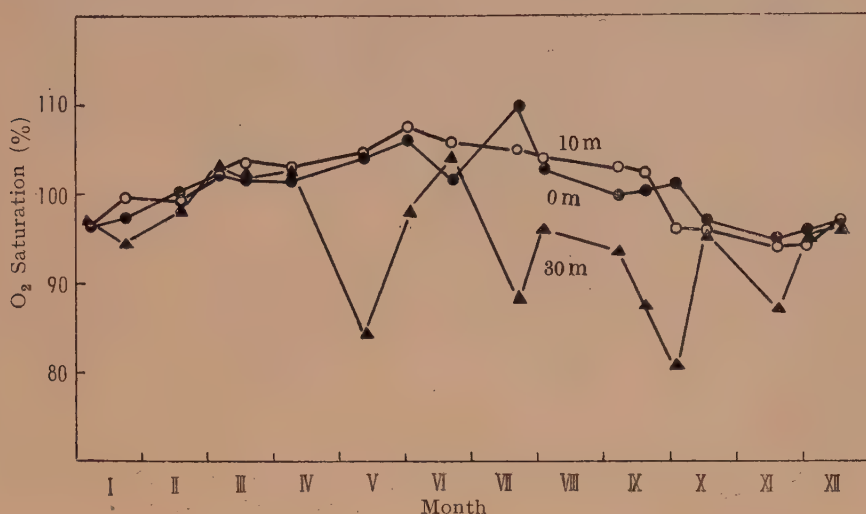


Fig. 4. Annual change of saturation of O₂ at different depths during 1953.

The percentage saturation exceeding 100% was observed during the period from March to September, and the highest value was 109.6% at the surface in early July and 107.4% at 10 m depth in early June. The lowest value was 80.5% at 30 m depth in early October.

SUMMARY

1. This article is a report on the oceanographical observations carried out as the routine work at the definite station during January to December, 1953.
2. In the annual change of water temperature, it was noticed that the maximum at the surface appeared in early August in this year.
3. The seasonal change of chlorinity in this year indicated that the chlorinity in 10 m and 30 m layers was less variable, while at the surface the remarkable decrease appeared in May and July.
4. The annual change of dissolved oxygen showed that the maximum value appeared in the spring season, the minimum in the autumn season.

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ON THE NOMURA AND TOMITA METHOD FOR MEASURING
THE MECHANICAL ACTIVITY OF CILIA*[†]**)†)

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(With 6 figures)

The Nomura and Tomita method for measuring the mechanical activity of cilia has many advantages over other methods (Nomura and Tomita 1933), and has been used by many workers, with some modifications in certain cases according to the kind of experiments.

In the present paper are given the original method and its main modifications with brief comments and some technical remarks.

THE ORIGINAL METHOD

1. *Principle.* When a small piece is cut out of the gill and immersed in sea water, the piece ("gill piece") will "crawl" on the bottom of the container owing to the reaction against the beating of water by the cilia on the surface. The speed of this crawl is measured in a graduated glass tube ("measuring tube").

2. *Preparation of gill pieces.* After carefully removing the right (upper) valve and a part of the mantle, a band of uniform width is cut from the ventral margin of each gill plate (fig. 1), which will shrink owing to mechanical stimulations on cutting. After a full recovery from the shrinkage each band is divided into nearly rectangular pieces by cutting along vertical ridges at equal intervals (fig. 2). The gill pieces thus obtained will crawl in the direction shown by an arrow in figure 2 on the bottom of the container. The gill pieces are left till the next morning, by which time active discharge of mucus will have ceased and the speed of crawl will have become practically constant. The gill pieces are now ready for use.

The width and length with which gill pieces are to be cut depends on the bore

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of the measuring tube to be used, for example, 3×4 mm for a tube with a bore of 10 mm, and 6×10 mm for a tube with a bore of 18 mm,

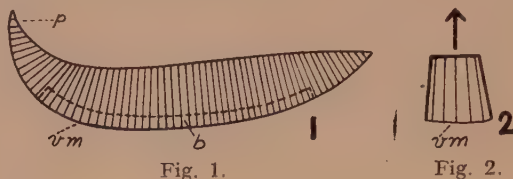


Fig. 1. Diagram showing the portion of a gill plate from which a band is cut for preparing "gill pieces." b, band; p, posterior end; vm, free ventral margin.

Fig. 2. Diagram showing a "gill piece," with its direction of crawl indicated by an arrow. vm, ventral margin.

3. *Measuring the speed of crawl.* The measuring tube is a straight glass tube, 10 to 18 mm in bore and more than 35 cm in length, which is graduated in millimeters and provided with a swelling like a cup at each end (fig. 3).

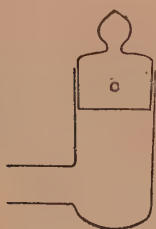


Fig. 3. A swollen end of the "measuring tube."

A gill piece is gently taken up in a small spoon having several holes and put in the swelling. As the bottom of the swelling is a little lower than that of the straight part of the tube, it is easy to keep the gill piece in the swelling for about 10 minutes. The piece is then duly oriented and allowed to crawl into the straight part. If the piece should tend to deviate sideward, the lateral elevation of the wall will prevent this, thus forcing the piece to crawl straight.

Measurement of the speed is begun about 5 minutes after the gill piece entered the straight part of the tube, by which time the piece will have recovered from disturbances due to the treatment of transfer. In reading graduations care should be taken to avoid errors due to parallax. While one measurement is being made the observer has to keep watching the crawl; if the crawl should be disturbed by mucus or some particle lying in the path, the measurement must be suspended until the piece has resumed a crawl free from such a disturbance. Usually, however, a gill piece may crawl with a very constant speed over a long distance unless disturbed mechanically or in any other way (fig. 4).

The speed of the gill piece in normal sea water is taken as 100 per cent and the speed of the same gill piece in an experimental solution is expressed in percentage of the normal, and the relative speed thus determined is taken as a measure of the mechanical activity of cilia of that gill piece. By using the relative speed instead of the absolute in this manner, differences in observed values due

to the individuality of oysters and to the shape and size of gill pieces can be eliminated, at least, to a large extent.

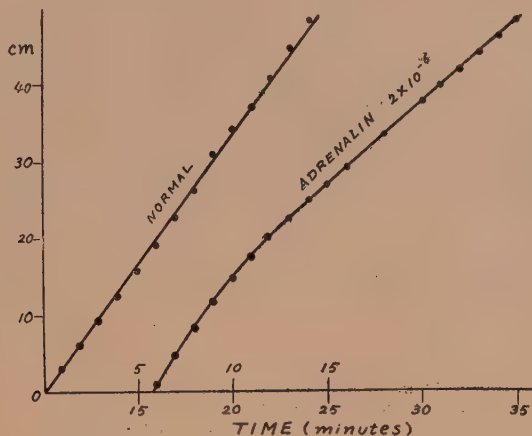


Fig. 4. Graphs showing the results of an experiment of exposure to adrenaline, throughout which the gill piece crawled quite smoothly. A right-angled measuring tube with a cock was used. Notice an almost constant speed in normal sea water and a gradual decrease in speed and subsequent uniform speed after exposure to adrenaline solution, 2×10^{-6} . (Re-plotted from Nomura 1937.)

MODIFICATIONS

1. *Measuring tubes with a cock.* In the original method, the procedure of exposing a gill piece to a solution involves the act of taking up and transferring the piece with a perforated spoon as mentioned before, which may stimulate the piece mechanically and affect its speed for at least a few minutes following the treatment.

In order that such difficulties may be avoided and a correct measurement of speed can be started "soon" after exposure to the experimental solution, two types of measuring tube with a cock have been devised.

(a) The right-angled measuring tube with a cock (Nomura 1937). The tube consists of two arms (A, B), joining with a well-ground glass cock (C), at a right angle to each other (fig. 5). The bore of the cock, about 10 mm, is equal to that of the arms of the tube, and allows the gill piece to slide smoothly in and out of the cock, otherwise the unevenness of the bottom surface of the tube would hinder smooth progress of the gill piece. In the experiment, the cock is first turned so as to be open to A and shut to B (fig. 5, left), then A and C are filled with normal sea water, and B with an experimental solution. After the normal speed has been measured, the gill piece is allowed to crawl further toward C. When the piece has entered C, the cock is turned counterclockwise to allow the piece to slide in B (fig. 5, right).

(b) The straight measuring tube with a cock (Tomita 1935). The construction of this type of measuring tube is the same as that of the right-angled one except that the two arms make a straight line instead of a right angle. Though this type of tube has some advantages in that the tube and its thermostat can be made more easily than the right-angled tube and its thermostat, and in that the straight tube requires less space than the other, the interface between the two media is more liable to disturbances at the time when

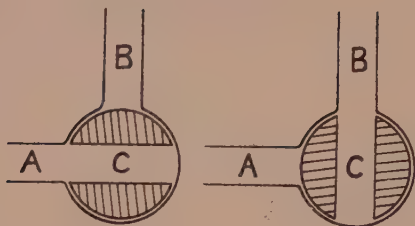


Fig. 5. Essential part of the right-angled measuring tube with a cock. Left: position of the cock allowing the entrance of the gill piece from the first arm (A). Right: position of the cock allowing the entrance of the gill piece into the second arm (B).

solution is used. The original method, however, is not convenient for such purposes, for it needs several assistants and many measuring tubes. Furthermore, the original method has some other disadvantages in particular cases (1) where only a small volume of an experimental solution is available, and (2) where the same portion of a measuring tube has to be used repeatedly to take readings with one or more gill piece (because it is difficult to remove masses of mucus that have been left on the bottom of the tube in previous crawlings). To suit to such particular cases, modifications have been introduced, (Tomita 1955) the main point of which consists in measuring the speed of a gill piece in a flat-bottomed vessel ("measuring dish") instead of the measuring tube.

The main part of the measuring dish is a shallow square dish ($5 \times 5 \times 1.5$ cm), which is built in the middle of a square glass plate (11×11 cm) by cementing four pieces of plate glass. The square glass plate can be obtained by cutting a waste photographic plate the gelatin of which has been removed. A sheet of coordinate paper ruled into 1-mm square is laid beneath the bottom of the measuring dish. Normal sea water or an experimental solution is put into the dish. Two small pillar-shaped glass pieces with well-polished surfaces, $0.5 \times 0.5 \times 4.5$ cm (fig. 6, M, N,) are placed as shown in figure 6 and parallel to a direction of lines of the coordinate paper. Ten gill pieces are put in area a of the dish and left undisturbed for 15 minutes or more. A gill piece is then moved gently with a glass rod to place b and is let to crawl toward c. If it tends to deviate to the right, it is gently moved to N and made to

the gill piece enters the new medium.

2. *The measuring dish.* In cases where fresh material is not available, and oysters stored for days without sea water are used for experiments, individual differences in their sensitivity to an experimental solution are sometimes much larger than those of fresh oysters. To obtain comparable results in such cases, therefore, it is desirable to use gill pieces from the same individual in all the experiments belonging to a series, and to repeat this series of experiments as many times as possible within a short period. Such experiments may become the more necessary when a readily decomposing solution such as an antiserum

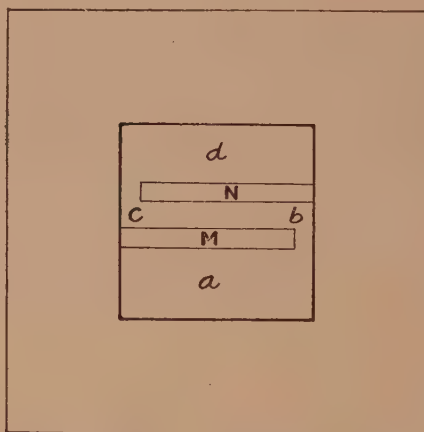


Fig. 6. Measuring dish seen from above, $\times 1/2$. M, N, pillar-shaped glass pieces along which gill pieces are made to crawl straight. a, d, areas where gill pieces stay before and after measurement of speed, respectively; b, c, start and goal of crawl of gill pieces for measurement of speed.

crawl along N; similarly, a gill piece deviating to the left is made to crawl along M. With a stop watch (graduated in 1/10 seconds) and a magnifier ($\times 4-5$) the time required for the piece to crawl 1 or 2 mm is measured, especial care being taken not to commit errors due to parallax. With the aid of the magnifier the observer should watch closely the crawl of the piece in order not to take readings while the piece is not crawling smoothly. After measurement, the piece is brought to area d, and a next gill piece is brought to b for measurement. In this manner, the time of 1- or 2-mm crawl is measured one after another with all the 10 pieces. The average of the speeds of the 10 pieces is then calculated. The average speed under experimental conditions is expressed in percentage of the normal average speed of the same group consisting of them 10 pieces.

The results of several kinds of tests indicate that if measurements are carefully performed, this modification, a much simplified method, is capable of yielding results more satisfactory than expected.

This modification, however, has some disadvantages in (1) that the measurement within about 15 minutes after exposure to a new solution may not always be accurate, and made (2) that the method is sometimes very inconvenient for performing the experiment at a constant temperature.

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纖毛の機械的活動性の“野村・富田式”測定法について¹⁾²⁾³⁾

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カキの鰓から切り取った小片が表面に密生している纖毛の水を打つ力の反作用で器底上を一定の方向に進むことを利用してその速力を測り、その鰓の小片の纖毛の機械的活動の尺度にするという野村・富田法(1933)が発表されてから、この方法は多くの人により種々の実験に用いられ、かつ、切片の速力測定するものに実験の目的に応じて若干の変法が考案されてきた。また、この方法を用いた研究者から教えられ、また著者自身の気のついた実施上の注意事項(未発表)も集積したので、ここにこれら細目をも含めて野村・富田法の原法と代表的変法をまとめて記述した。

この方法は1932年浅虫臨海実験所で生まれたもので、この方法を着想され、實際的操作法の考案・試験に私をして協力せしめられた現臨海実験所長野村七録教授に深く謝意を表する。

野村・富田法の原法

(1) 方法の原理

カキの鰓の遊離縁から切り取った小片(以下、切片と略称)を目盛つきのガラス管(測定管)に入れ、表面の纖毛が水を打つ力の反作用によつて切片が一定の方向に進行する速力を求め、これを纖毛の機械的活動性の尺度とする。(図と文献は英文と共通)

(2) 鰓の切片の作り方

a) カキの背側から殻の間に金属製へらをさし込み、貝の軟い部分を害さぬよう注意してまず貝柱を上方の殻から切り離し、次に外套膜を少しずつ離しながら静かに上方の殻を除き(乱暴に殻を持ち上げると外套膜と共に鰓まで引き上げて損傷する)、残りの部分を深めの皿の中の海水に入れる。

b) 外套膜の一部をはさみで切除、鰓の全面を露出、細いピンセットと小さいはさみでまず一番上の鰓葉の遊離縁に沿ひ数ミリの幅(後記)のバンドを切り取る(第1図)。次にこの鰓葉の残りの部分を付け根から切除して2番目の鰓葉を完全に露出、前と同様にバンドを切り取る。このようにして全鰓葉(4枚)からバンドを作り海水に入れておく。バンドは初めは切断による機械的ショックで非常に縮まるが1-2時間放置すると十分にゆるんでゐる。慣れないうちは、貝の体に付いたままの鰓葉からいきなりバンドを作りにくいから、まず4枚の鰓葉を次々に根元から切断して海水中に放置、十分にゆるむのを待つてバンドを作るようにしてもよい。

c) バンドが十分にゆるんだら鰓葉の縦のひだに沿つて一定の間隔(後記)ではさみを入れ切片を作る(第2図)。切片は切断による収縮(幅の)から回復すると盛んに器底を動き回る。切片切断の際、残つたバンドの端も縮まることが多いから、それを計算に入れて次の切り目を入れないと、回復してゆるんだあとで見ると幅の広過ぎるものになつてゐる。鰓葉の前端および後端近くからは切切片を作らない。

d) 切片は冰箱その他なるべく温度の低い場所に放置、翌日実験に供する。この時まで

1) 東北大学名誉教授畑井新喜司先生に捧ぐ。

2) この仕事の一部は東北大学臨海実験所後援会研究援助費による。

3) 浅虫臨海実験所業績 第217号

には切片はもちろん十分にゆるみ、表面から粘液の出ることも少なくなっている。

e) 切片の大きさは、あとで詳述するように、太い測定管を用いる場合には大きく(最大 $6 \times 10 \text{ mm}$)、細い測定管の場合には小さくする(最小 $3 \times 4 \text{ mm}$)。また、同一個体からできるだけ多くの切片を作つて一連の実験に用いたい場合には切片の幅を小さくしなければならない(それに応じて長さも)。

(3) 測定管

切片を適當の太さのまつすぐなガラス管に入れ、位置を正して切片が反対の端のほうに進むようにすると、切片が進行中に左右いずれかに曲がりかけても管壁の傾斜がそれを妨げる役目をし、切片の形がよほど不正なために曲がる傾向が非常に強くない限りは一直線に進ませることができる。この進行を観測するための目盛には、1 ミリ目の方眼紙を管底に外からはりつけ、暖ためて溶かしたパラフィンを一面にその上から塗つて防水したものか、特に注文してガラス管のものに1 ミリごとの目盛をつけたものを用い、急場のまにあわせには50ccのビューレットの太さ一様(従つて目盛も等距離)のものを選んで使うこともできる。

測定管は内径1.0–1.8 cm 程度、長さ35 cm 以上のものがよい。太い管を使う場合には切片も大きいめに作り、細い管の場合には小さいめにする(上記)。実験溶液の分量があまり多くない場合は細めの短い測定管を用いる必要がある。

管の両端には第3図のような壺を作り、小孔付きのすり合わせ栓を具えさせると切片や液の出し入れなどに便利である。測定中は一方のための栓をふさぎ、他方では小孔によつて内外を通じておく。

(4) 切片の取扱法と速力測定法

a) 特別のさじとガラス棒：鰻の切片を測定管その他の容器に出し入れするには、数個の穴のあいた小さい丸さじを用いる。これには、柄の両端に大小2箇(径1.2, 1.5 cm)つけ、クロムめつきしたものが便利である。測定管端の壺の中などで切片の位置を正すには先端を細く引いて曲げてつぶしたガラス棒(代用には細いピンセットや解剖針)を用い、できるだけ機械的ショックを与えぬようにする。

b) 測定管に切片を入れること：切片は上記のさじで静かにすくつて管端の壺に入れる。この取扱のため切片が多少とも縮むのが普通であるから回復するまでしばらく待つ。ための底は管底よりも少し低くしてあるから(第3図)、切片は壺の底を動き回るだけで管の直線部にはあまり進入しない。もし進入しそうになったらガラス棒(上記)で静かにもどしてやる。このようにして10分ほどしたらガラス棒で位置を正して切片が管内に進入するようにし、直線部を5分間ほど進ませたあとで測定を開始する。

c) 読みの取り方：正常切片の速度(10秒間に5–10 mm 程度)またはそれに近い速さで走っている切片については5 mm または10 mm 動くのに要する時間を秒時計(1/5 または1/10 秒きざみ)で測り、速度の低下している切片についてはそれ以下の距離を動くに要する時間を測る。切片がある目盛を通る瞬間を決定するには目が絶えず切片のま上にあるように走る切片を追い、いわゆる parallax の誤差を防がなければならない。読みを取っている間は切片から目を離さずに注視し、万一その進路が曲がつたりごみや粘液のために速さが変わるような異常を認めたら、その読みを中止して、順調にもどるのを待つ。

粘液の分泌が盛んでないような実験条件の場合、必要の注意を怠らないと、30 cm 以上も継続的に順調に走ることは普通である。そのような場合の代表例を第4図に示した。

d) 粘液とごみの問題：切片の表面からは絶えず少しずつ粘液が出、* 繊毛運動によって運ばれ、結局切片の後端の一隅に集まり、しばらくはそれを付けたまま進行を続けるが、この状態の粘液塊は走行速度にほとんど影響しない。しかし、この粘液塊がたまたま器壁に接触すると速さが落ち、時には粘液が器底に付着して進行を止めてしまう。そのうち切片は粘液塊をそこに置き去りにして再び走り始めるが、粘液塊から離れた直後3-4秒の間一時速さを増すことがある。測定にはこのような異常の場合を確実に避けるよう絶えず注意していなければならない。また、たまたま液中に混入したガーゼや濾紙の繊維くずなどの小さなごみが(時には肉眼で見のがす程度のものでも)切片の速度を乱すことがあるから上と同様の注意を要する。

e) 繊毛の機械的活動性の表わし方：切片の速力を求めるには、1箇の切片について普通5回の読みを取り、その平均から換算する。しかし、速力の絶対値は切片の大きさ・形などにより必ずしも一様でないから、常に各切片の実験前の正常速度を100とした場合の相対値を絶対値の代りに用いることによつてこの難点を消去し、それをその時の繊毛の機械的活力とするのである。

f) 恒温槽：測定管には必要に応じて恒温水槽を用いる。長い管を何本か並べるので特別に各自が工夫して作る必要がある。水槽内の水の攪拌や定温の水の循環などにモーターを用いる場合にはその振動が測定管に響かぬよう特に注意しないと仕掛倒れになつてしまう。特別に精密な定温を必要としない限りは、簡単なトタン製の細長い箱の中に測定管を横たえ、温水または冷水を時々静かに槽内に注加、瓶洗いのブラシで静かに攪拌するというような原始的な方法でもまにあう。

g) 切片の表裏の図別：切片をいつたん測定管から出し、あとでまた入れて測定するような場合、切片が前と同じ面を下にして走ることを確かめる必要がある。* それには、切片の後端を拡大鏡で検査して、小さな粘液塊やごみがどちらの隅についているかを確かめるか、切片全体の形をノートしておく。また、切片を作る際に前端の一定の隅を斜に少し切り取つておいてもよい。

野村・富田法の變法

(1) コック付き測定管を用いる變法

原法では、切片を実験液に入れる時どうしても切片をさじですくつて出し入れしなければならないので、実験液に移して切片が機械的ショックによる収縮から回復するまでは正しい速度測定を始めることはできない。これは実験液に入れたすぐあとの影響を知るのに非常に都合が悪い。この不都合をなくするためにコック付き測定管が考案された。すなわち、測定管の途中に管の内径と等しい内径の穴を有するコックを置き、一方の腕に正常海水を入れ、他の腕に実験液を入れ、単にコック開閉によつて切片を実験液に移す方法である。コック付き測定管には両腕がコックを間に直角をなすものと(野村 1937)、一直線をなすもの(富田 1935)との2種類がある。コックの内孔の底面と両腕の底面とはびつたり合つていなければ、一方から他方への円滑な進入が行われない。また、目的によつては、一方の腕をコック近くですり合わせにし取り

* 切片の作りたてには非常に多量の粘液を出す、一晩置いておくうちにその量はずつと減少する。しかし、それでも絶えず少しずつ分泌される。

** ただし、正しい形に作つた切片では表裏による速度の差はほとんどないのが普通である。

はずし自在にしてもよい。このすり合わせ並びにコ・クのすり合わせが完全でなければならぬのはもちろんである。

コック付き直角管(第5図): まずコック C を B に対して閉ざして B 内に実験液を入れ、B 腕の遊離端の栓をしめ、次に A およびコック内に正常海水を満たす。切片を A に入れ正常速度を測り、切片がコック内に進入したら静かにコ・クを回して B と連絡させ切片を B に迎え入れて後、再びコ・クを回して B との連絡を絶つ。万一、コックの中で切片の走行に故障を起したら、測定管を静かに傾けて B の方への進入を助ける。切片が A から C に進入したあとコックを B に対して開いてから切片が移つたあと再びコ・クを閉じるまでの間に実験液と正常海水との間の界面に若干の乱れを生ずるし、また、実験液に進入の際に切片が一時収縮することがあるので、実験液進入の“瞬間”から正しい測定を開始することはできないが、他のどの手段によるよりも早く読みを取り始められる。

コック付き直線管: 直線管は直角管よりも製作が容易で、それを入れる恒温槽も簡単に済むが、コ・クの所における正常海水・実験液間の界面は直角管の場合よりも乱れやすいから実験液進入直後の読みはそれだけ不正確である。

(2) 測定皿を用いる変法

カキの入手が不便で、数日分まとめて材料を取り寄せ、水から上げたまま冷蔵庫の中に使うまでしまっておくような場合には、保存状態・保存日数などによつて種々の実験条件に対する各個体の抵抗性が非常に違うことがある。また、抗血清その他短期間に変化または減力しやすい溶液を実験に用いることがある。こういう場合には、一系列に属するすべての実験を同一個体から作つた切片を用いて行い、それを短期間に多くの個体について繰り返すことが望ましいが、多数の観測者が多数の測定管を用いてやらぬ限り測定管法では実行困難である。また、実験液をできるだけ節約したい場合や粘液分泌を促すような実験液を用いる場合に都合が悪い。このような特別の場合を困難に対処するため、測定の精度を多少犠牲にして講じた便法がこの測定皿法である。

この方法では測定管の代りに 5cm 四方、深さ 1.5cm 前後の底の平らな浅い容器(以下、測定皿と略称)を用い、これに切片を 10 箇入れ、皿の下には 1 ミリ目の方眼紙を敷き、各切片が 2mm または 1mm 走するのに要する時間を 4-5 倍の拡大鏡と 1/10 秒きざみの秒時計を用いて測定、それから各片について走行速度を計算、10 片の平均値を求め、正常海水中の同様の平均値を 100 とした場合のその相対値をもつてこの実験条件下の纖毛の機械的活性の強さとするのである。

測定皿(第6図)は非常に平滑な板ガラス(11cm 四方、使い古しの写真乾板の膜をはがしたものである)の中央に、それを底として 4 箇板ガラス片で囲んだ皿(5×5×1.5cm)を接着剤(たとえばビセイン)でつぎ合わせて作る。

切片を一直線に進ませるには表面をよく磨いた角柱状のガラス小片(0.5×0.5×4.5cm)2 箇を用いる(第6図, M, N)。両者 6-8mm の間隔で平行に置き、切片が左に曲がる傾向を持っていたらガラス棒の先で静かに小柱 M (進行方向に対して左手にある小柱)に寄せ、M の内側面に沿つて走らせ、右に曲がる切片には反対側の N を用いる。この工夫は測定管内におけるよりも確実に切片の直線的進行を誘導する。M, N は同時に測定皿の仕切りの役目も兼ね、初め切片は a に全部入れ、1 箇ずつ b に寄せて c の方に走行させて測定し、終つたら d に入れる。

測定管の場合と同様 parallax の誤差に注意して読みを取り、また、絶えず拡大鏡で注視して切片が確かにごみや粘液にじやまされずに走つた時に測定値の読みを取ることにすれば、測定管よりも精度がひどく落ちることはなく、しかも前に述べたような特別の場合の測定管法の難点を少なくともかなりの程度に解決できるのである。ただし、この変法の難点の 1 つは実験液の影響を実験開始直後から正確に追求できないことで、また、恒水槽その他により定温に保つのに不便である。

東北大学附属臨海実験所創立卅周年

記念祝賀記事

臨海実験所長 教授

野村 七 録

助教授 平 井 越 郎

東北大学附属浅虫臨海実験所は大正十三年(1924)七月五日目出度くその開所式を挙行した。爾來年をけみすること卅年、その間本実験所に於て臨海実習を受けた学生数は三百名を超え、その中より多くの優秀なる教授或は研究者を輩出し、我国生物学界に於て枢要なる地位を占むるに至つたことは慶賀に堪えない次第である。また本実験所所員、本学生物学教室教職員及学生並に学外からの研究者によつて本実験所に於て行はれた研究はおびたゞしい数にのぼり、その報告は国内は勿論世界中の指導的立場にある著名の臨海実験所其他の研究機関に広く配布せられ、その価値は高く評価せられている。我実験所はかくして世界の学界に高い地位と名声とを得るに至つた。浅虫に臨海実験所を設立したことは即ち成功と云ふべきである。

従つて実験所員は創立卅周年記念祝賀事業は正に盛大なるべきものと考え、前年以來出来るだけ愉快なるプログラムを編成するに大なる努力を払つた。先づ県及び浅虫村の地元を含め、実験所及び実験所後援会を綜合して卅周年記念祝賀協賛会が組織された。数回に亘り協議の結果、地元から20万円、後援会から30万円の援助費が可決せられた。かくて諸行事の準備がすべり出した。

祝賀の催しは二段に行はれた。

所内の祝賀

第一には内輪の祝賀であつて、記念日当日即ち7月5日実験所員及び丁度当時臨海実習を行つていた本学生物学教室の職教員及学生のみが参加した。総員凡そ六十名である。その訳は実験所では場所が狭いので外から多数の御客を招待することは出来なかつたからである。

記念日当日午前10時一同実験所本館屋上に参集、平井助教授開会を宣し、野村所長式辞を述べ、加藤教授祝辞並に外遊途上にある元村教授からの祝電を樋渡講師の披露があつて式は閉ぢた。間もなく総員「みはらし亭」に移つて祝賀の昼餐会を催した。

野村所長、加藤教授、樋渡講師、臼杵助手、森山留五郎君(創立以來の職員で、現在は財団の方の雇)、学生代表等の祝辞や懷旧談があり、御赤飯その他の御馳走を味つて和氣霽々の裡に会を閉ぢた。午後は1時から浅虫中学校庭に於て三年生対四年生(四年生勝)及び中学校対実験所(中学の勝)の野球試合を行つた。夕食後は寄宿舎食堂に於て学生側がコンパを催し職員も招待された。祝賀協賛会からは特に御祝の御酒が提供せられテーブルスピーチは何時か咽自慢の会となり一夕の歡を尽した。

一般祝賀行事

青森県及び浅虫(野内)村の協賛の下に 8 月 20 日から 22 日三日間に亘つて多彩なプログラムを以つて盛大な祝賀諸行事が施行された。県と村の援助に対して我々は茲に深厚なる謝意を表明する次第である。

祝賀プログラムは次の如くである。

8 月 20 日

1. 祝賀式典 午前 10 時 於 浅虫中学校
2. 祝賀昼餐会 同上
3. 祝宴 午後 6 時 於 東奥館
4. 映画会 午後 7 時半 於 浅虫中学校
 - (イ) 海水からマグネシウムの製造
 - (ロ) 汐干狩
 - (ハ) 南極の秘境

8 月 21 日

5. 記念講演会

青森市野協中学校に於て……午後二時

(イ) 海と食糧

東北大学教授 理学博士 今井丈夫

(ロ) 日本史上の青森県

東北大学教授 文学博士 古田良一

浅虫中学校に於て……午後一時

(ハ) 虫の暮らし

東北大学教授 理学博士 加藤陸奥雄

(ニ) 人を化かす動物

東北大学教授 理学博士 永野為武

8 月 20 日より 22 日

6. 水族館 入場無料 昼夜開場

8 月 21 日より 22 日

7. 実験所参考品展覧

8 月 21 日

(花火大会 於浅虫海岸 観光協会主催)

プログラムは以上の如く甚だ多彩であるが、これに加えて行事の模様を簡単に記述することにする。

八月廿日祝典当日は曇稍小雨の天候であつたが、大したこともなく参会者も揃つたので定刻より少し後れて、平井助教授開会を宣し、野村所長式辞を朗読した。

所長は先づ当日の参会者一同に対して、多忙中の参列を謝し、また多年に亘り実験所の発展のために与えられた協力と援助並に今回の祝賀行事にあたり与えられた支援とを感謝し、実験所の歴史を讃え、更に向後の繁栄を希念した。続いて高橋総長から初代所長畑井新喜司名誉教授並に前所長小久保清治名誉教授に対してその功績に報いるため感謝状及び記念品(津軽塗文庫)を贈呈した。また森山留五郎、高橋作次郎両君の実験所創立頭初から多年に亘る忠実なる勤務に対して、野村所長から表彰状並に記念時計が贈呈された。続い

て浅虫小学校校外児童会の代表 10 名が先生に引率されて現はれ総代の成田君が所長の手から感謝状と記念品とを受けて喝采を博した。これは水族館周辺の清掃に奉任した労をねぎらうためであつた。

次の諸氏の祝辞があつた。

文 部 大 臣	(教育大学教授 高槻俊一氏代読)
本 学 総 長	高 橋 里 美 氏
弘前大学学長	郡 場 寛 氏
青森県知事	津 島 文 治 氏 (横山副知事代読)
青森県会議長	中 島 清 助 氏
衆議院議員	山 崎 岩 男 氏
同	淡 谷 悠 蔵 氏
浅 虫 村 長	赤 坂 市 三 郎 氏

祝辞に続いて、山形大学学長、実験所旧職員川村輝良、松谷善三両君、渡米途上の元村教授、及び柘植秀臣君等からの祝電披露があつた。

祝典は正午に終り、小憩の後、祝賀昼餐会が始まつた。所長開会の挨拶を述べ、多数の参会を謝し殊に祝賀行事に対する地元の協力援助に対して礼を述べた。畑井、小久保両名誉教授から祝辞があり、弘前大学学長郡場博士の音頭で乾盃し万才を三唱した。卓上には赤飯その他折詰の御馳走があり、また御祝酒が添へられたが、御銚子と盃とは特に卅周年のため誂へたもので、記念として各自御土産に持ち帰るようにしたものである。テーブルスピーチと歓談がはづんだところで、渡辺理学部長の御挨拶で盛会裡に会を閉じた。スピーチはテープコーダーに記録した。招待状は 195 人に発したのだがその中 95 人の出席である。

夕刻になつてから浅虫中学校に於て映画会を催した。主として学生生徒 800 名の観賞があり盛会であつた。

若者が映画を楽しむ頃主なる来賓名士連のために東奥館に於て祝宴が催された。渡辺理学部長の挨拶で開会され下記の 34 名が出席した。

郡場寛氏(弘前大学学長) 時田郁氏(北大水産学部長) 横山武夫氏(副知事) 小館善四郎氏(画伯) 森豊秀氏(浅虫中学校長) 平田直司氏(東奥館主) 赤坂市三郎氏(村長) 畑井新喜司氏(初代所長) 小久保清治氏(前所長) 高槻俊一氏(教育大学教授) 小林佐太郎氏(京都工芸繊維大学教授) 阿部襄氏(山形大学教授) 小林新二郎氏(北大、水産学部教授) 石田周三氏(千葉大学教授) 古田良一氏(東北大学教授) 今井丈夫氏(同上) 木村有香氏(同上) 長尾昌之氏(同上) 神保忠男氏(同上) 加藤陸奥雄氏(同上) 佐藤隆平氏(東北大学助教授) 富田軍二氏(同上) 山本護太郎氏(同上) 樋渡宏一氏(東北大学講師) 内田英二氏(東北大学事務局長) 菅沼隆氏(同庶務課長) 曾我鉦氏(同理学部事務長) 今野富美治氏(同庶務係長) 野村七録氏(実験所長) 平井越郎氏(実験所助教授)

昼の祝典と異り打ちくつろいで、祝辞につぎ盃も廻り歌や舞踊の余興も加はり、甚だ賑やかに時を過し、一同歓をつくして九時頃盛会裡に幕を閉じた。

同 窓 会 東奥館の祝宴後、生物学教室の同窓生は所長官舎で更に同窓会を催した。昔浅虫で臨海実習をやり、或は更に所員として浅虫に勤務した十五名計りの浅虫が恋しい。

連中ばかりである。歓談夜半に及んだそうである。

記念講演会 本学の四教授によつて青森と浅虫とで同時に通俗講演が行はれた。青森に於ては県の社会教育課と東奥日報社の後援により、一般聴衆を対象としたものであつたが、浅虫に於ては主に青少年学生生徒を対象としたものである。青森に於ては今井教授は先づ浅虫臨海実験所の歴史から説き始め、世界の臨海実験所及び海洋調査に論及し食糧問題や海洋資源に就いて興味ある御話をした。古田教授は日本の歴史上に於て青森県が最初に文献に現はれた時の事を論じ、また津軽、八戸、下北の各地方の明治維新に至るまでの栄枯盛衰の跡をたどつて県民の特別な興味を喚起した。聴衆は凡そ 150 人、主に学生教師達でまた若干の水産業者も見けられた。

浅虫に於ては加藤教授は昆虫殊に蚊と蠅に就いて生態学的観点から有益なる御話をせられ、屢昆虫に縁のある俳句を引用して興味を増した。永野教授は演題からも分るように、伽倻の狸の話等を引張り出して面白おかしく笑せた。聴衆凡そ 500 名で盛会であつた。

花火大会 これは地元殊に観光協会が主催で行つたもので、実験所自身の行つたものではないが、よく両者の緊密な連絡によつて、特に実験所の創立卅周年祝賀に際して挙行したもので、地元の協力がよく顕はれている。花火代百万円と唱へ豪華なもので、県内は勿論県外からも多くの見物人集り浅虫は人で埋まり宿屋は言葉通りの超満員であつた。実験所の卅周年は従つて一般地方人にも広く知れ亘つた次第である。

記念号発行と記念四阿の建立 以上の多彩なる祝賀行事に加え、更に同窓生間に実験所研究報告の記念号を出して欲しいとの要望があつた。そこでまづ所長は実験所後援会の理事会に提議してその費用の協賛を得た。また水族館入場者のための休憩所も長年要望せられていたので記念事業の延長としてこれも此際建設し度いと希望したところ、理事会の快諾を得て実行に移すことになつた。茲に同理事会に深謝の意を表する次第である。

記念号は初代所長、前所長をおはじめ、旧職員同窓生等一度は浅虫臨海実験所で研究したことのある研究者の論文と追想録を集録したものである。論文の多くは畑井先生のお弟子の書かれたもので、従つてまた畑井先生記念号と云ふ含みも多分にあり、各論文は畑井先に捧献されたものである。

以上に筆者等は実験所卅周年の記念祝賀行事を略述したが、更に此際実験所の創立前後からの沿革や現状、研究活動その他の事を記すことは時宜を得たものと考えるのでもう少し筆を続けることにする。

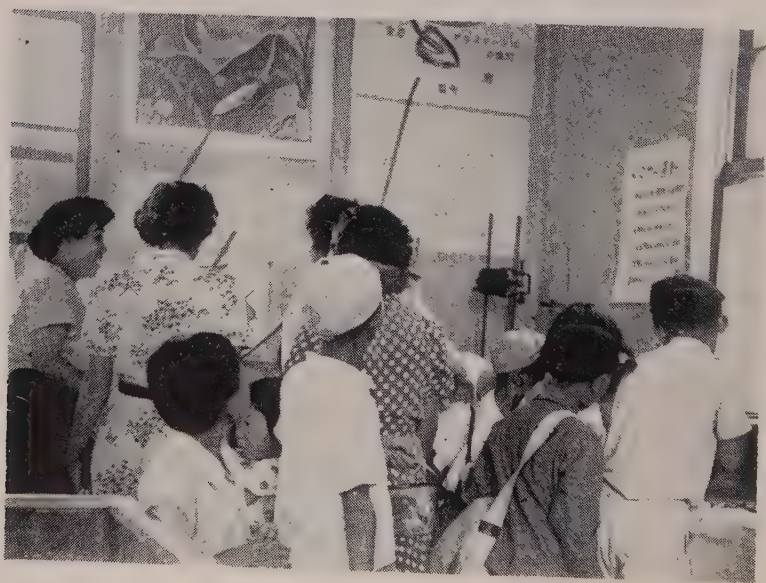
沿革 東北帝国大学は大正の中頃より生物学教室及び臨海実験所を創設する計画を有したが、当時の総長小川正孝先生は東京帝国大学教授五島清太郎先生に諮り、その推薦によつて、当時米国フィラデルフィアのウィスター研究所教授畑井新喜司先生を招聘して、その設計にあたらせることになつた。畑井先生は大正十年歐洲を経て帰朝せられ鋭意生物学教室及び臨海実験所創立の準備に努められた。総長はじめ大学当局の努力によつて大正十二年第四十六回帝国議会に於て臨海実験所創設費 150,000 円が通過し、また青森県が水族館創設費として 50,000 円を寄贈することとなり、愈々多年の希望が実現することになつた。実験所敷地は当時衆議院議員だつた故野村治三郎氏及び現東奥館主平田直司氏祖父義造氏の共同寄附によるものである。(野村氏はその母堂ふん殿及び長男市三郎殿両名の名義で寄附)

畑井先生は、大正十年から十一年(1921-1922)に亘りはじめは故朴沢教授(当時助教授)及



左 花火大会

下 実験室展覧



び筆者野村と、後には故野村益太郎教授(当時助教授)及び筆者野村等と共に東北地方各地の海岸をつぶさに調査し、浅虫の地を最適としてそこに実験所創設を決定した。建物の工事は大正十二年五月に始まり翌年完成した。

大正十三年七月八日の勅令第157号により実験所の官制は発布された。本実験所は東北帝国大学理学部に附属すること、所長は理学部教授或は助教授の中から文部大臣が任命すること、所長は本学総長監督の下に所務を所理すべきことが規定せられた。

開所式は大正十三年(1924)七月五日実験所近くの平地所謂“千畳敷”即ち明治十四年(1881)八月廿八日に明治大帝が東北御巡幸の折に御小憩遊ばれた地で現在その記念碑の建つてある地に臨時に天幕を張つて拵えた式場に於て浅虫開闢以来の厳肅さで行はれた。また引続いて同じ場所に於て、祝賀会が催され、地元の協賛によつて余興や御馳走もあり、賑やかに実験所の誕生が祝福された。畑井先生が初代所長に任命せられ、昭和十三年停年制によつて御退官される迄所長として一意専心実験所の発展に尽力せられた。先生は最初から研究殊に動物生理学の研究に重点を置かれたので、先生の門弟等により開所式後間も存く続々として重要な研究が発表せられ、浅虫実験所は仙台の生物学教室と共に我国に於ける動物生理学揺籃の地として内外に重きをなすに至つた。

歴代所長の氏名、専門及び任期は下の如くである。

1. 畑 井 新喜司 (動物生理学, 神経学) 1924-1938 (大正 13- 昭和 13)
2. 朴 沢 三 二 (動物分類学) 1938-1940 (昭和 13-15)
3. 野 村 益太郎 (実験動物学, 動物分類学) 1940-1942 (昭和 15-17)
4. 野 村 七 録 (動物生理学, 生物物理化学) 1942-1944 (昭和 17-19)
5. 朴 沢 三 二 (動物分類学) 1944-1947 (昭和 19-22)
6. 小久保 清 治 (浮游生物学, 湖沼学) 1947-1953 (昭和 22-28)
7. 野 村 七 録 (動物生理学, 生物物理化学) 1953 (昭和 28-現在)

歴代所長の氏名を書並べて見て、第二代及び第三代所長の御永眠に対し哀悼の意を新たにするものである。逝去或は退職によつて創立頭初の実験所員は現在一人も居なくなつた。そして創立準備時代からの歴史を知つて居るものは、実験所及生物学教室を通じて不肖現所長一人のみとなつた。それで、此際出来るだけ詳しく実験所の歴史を書き残すことは筆者の義務と考えられる。

仙台の生物学教室は実験所に先立つこと一年即ち大正十二年に開講し、その理科報告第一巻は大正十三年に発刊せられたが、実験所の業績は早く既にその第一巻第一号に登載せられた。その第一号は関東大震災のために東京の各印刷所が壊滅したため、臨時にウイスター研究所印刷部に於て印刷したものである。序ながら畑井先生と故野村益太郎教授(当時助教授)及び筆者は、開所式の前年夏既に東奥館の別棟のクラブと称する建物の一室に於て多くの不便を忍んで既に盛に研究を始めていたのである。その結果の一つは筆者のヒトデの受精素(ファーターリジン)の研究報告で、日本では最初のものである。これは畑井先生に鞭撻された御蔭によるものであるが此辺にも先生の研究熱の旺盛なものと且またセツカチな御気象がよく現はれてゐるのである。

交通と環境 浅虫駅は東北本線で急行車ならば東京から凡そ13時間半、仙台から7時間半の距離にある。青森からは昼間はバスが一時間に二三回発し、45分位で浅虫に達する。浅虫駅から実験所迄は徒歩凡そ20分(凡2キロ)であるが、タキシーもあるし、ま

た夏の間は乗合舟の便もある。夏泊岬は陸奥湾を略二分し、東に野辺地湾、西に青森湾を控へる。浅虫は周知の如く有名な温泉地であるが、その略東北に、夏泊岬から西に向つて更に一小岬が延びその先端に実験所が位して居る。実験所は西に青森湾を望み、東は小山に面する。敷地は凡そ 25,740 平方米 (7,821.96 坪) で寄附当時 39,480 円と見積られた。附近の海上には湯島、鷗島、茂浦島等点在し景色甚だよく、海水清明にして海岸は低い崖或は礫、岩或は石浜多く汀線は屈曲出入が多い。ウイスコンシン大学の M. F. Guyer 教授は嘗て本実験所を訪ねその環境の景観と近代的設備の優れていることを大いに賞讃した (The Scientific Monthly, 1929, vol. 29, p. 383~393)。然し年が経ても景色は変わらないが、卅周年を迎えれば建物の荒廢も甚しくなり、往年の近代的設備も學問の進歩につれて改善を要すること多くこれが実験所此頃の悩みの種子である。気候は間近の青森に比し年平均で二三度高く、夏は涼しく研究に適す。普通の避暑地に於ける如き喧騒からなやまされることなく俗塵を離れた別天地である。

Fauna と Flora 附近は動物豊富で実習及び研究用の材料として不自由はない。沿岸漁業も相当に盛である。

仙台の財団法人斎藤報恩会の援助によつて陸奥湾の広汎なる生物調査が行はれ、これによつて湾内の生物相が明かになつた。

設備 実験所本館は二階建、煉瓦及びコンクリート造り、389 平方米 (凡そ 150 坪) で、15 室及び廊下に区切られている。その中 8 室は所員用、二室は学生実習室、その他応接室、写真暗室、図書室、小使室、生化学研究室等である。尚、海中実験室、海中生洲、硝子張タンク室等ある。各室は海水、淡水及電気を供給せられる。海水は実験所の裏のポンプ室で近くの点から汲み上げるが、急に深いので水は清潔である。一旦海水タンクに貯えてから各実験室及び水族館に鉛管によつて配布されるが、鉛管は海水に殆ど毒性を与えないと信ぜられる。

階下の実習室は主に一般動物学 (加藤教授) 及びプランクトン (平井助教授) の実習に使用し、階上の実習室は動物生理学 (野村教授) 及び発生学 (元村教授) の実習に使用される。図書室は単行本、叢書類定期刊行書等重要な図書で充満している。水族館の建物は凡そ 238 平方米で、24' けの水槽を有し大小種々である。玄関広間の丸形水槽は直径 2.45m、深さ 1.36m で多くは海産哺乳類や大形海産動物に用いられる。建物の一側には 11 の水槽があり、その一は $2.95 \times 1.41 \times 1.81$ m. で 5,657 立を収容し、他は $1.35 \times 1.45 \times 1.81$ m. で各 2,589 立を容れる。他の側には 12 の小水槽があり、 $0.57 \times 0.57 \times 0.60$ m. で各 308 立を容れる。

水族館の一般公衆への観覧は原則的には毎年五月に始まり十月に終る。観覧者の年間総数は近年平均して 15 万人を超え海洋生物学普及に大なる貢献をしている。標本室は小さい木造で、小山の中腹に建てられて、凡そ 9 坪である。標本は海産動物のみならず、陸奥湾調査の時に採集した鳥の剥製も含む。

寄宿舎 木造 263 坪で一部二階、大体一階建で学生用 10 室、応接室、食堂、台所、浴場を有し、また賄方小使のため二室あり、総体で凡そ 50 名を収容することが出来る。常住職員及び来訪研究者のために住宅 5 棟ある。実習船“こたか”は長さ凡そ 8.5m、三噸 20 馬力、ガソリンモートル、速力 3 哩の性能を有する。30 年間に亘り、定常の仕事、研究、採集、人員及び荷物の運搬に活用せられたが最早老齡に達して更新を要

する。外に小形モーターボート及び和船がある。建物では外に物置、ガソリン貯蔵庫、切符売小屋等がある。

所 員 現在は次の如き職員を有する。

所長(兼任): 教授 野村 七録 (動物生理学, 生物学教室)
 助 教 授 平井 越郎 (分類学, 浮游生物学)
 助 手 沖津哲三郎 (浮游生物学)
 津幡 文隆 (海洋学)
 小久保三郎 (生理学)
 相川 豊夫 (生理学)

雇 傭 員 5 名

臨海実習 生物学教室に於ける授業の延長として、毎年7月初め頃から各科1~2週の臨海実習が行はれる。その科目及び担任者は次の如くである。

一般動物学 加藤陸奥雄教授 (生物学教室)
 浮游生物学 平井越郎助教授 (実験所)
 動物生理学 野村七録教授 (実験所及生物学教室)
 発 生 学 元村勲教授 (生物学教室)

実験材料は主に浅虫に於て豊富にして、仙台その他海から遠い教室では入手し難い生物を充分に利用して、海洋生物学の諸面に親しませ、将来の研究に広い分野の道を開かせる。

終戦後は山形大学、弘前大学等の他所の学校も此処の施設を利用するに至つた。その場合授業は本所員或は各自の職員によつて授けられる。

研 究 初代所長畑井先生が最初から研究に重きを置いたことは前に述べた如くであるが、此の伝統は今に至るまで引き継がれている。それは業績表の示す如くである。実験所の業績の中最も大きなものの一つは、前述の如く仙台の財団法人斎藤報恩会の援助により全国の生物学者多数の協力を得て行つた陸奥湾生物調査である。その資料は1926-1928に亘り採集せられ、各専門家に送られて研究され、その結果は多年に亘つて理科報告に発表せられた37篇の論文である。これは我国海洋生物学に寄与したこと勿論大であるが、兎角縄張り主義や独善主義に陥り易い我国に於て多数の分類学者がよく協力一致して此の難事業を遂行したことはまことに画期的な成功と云はなければならない。此の計画をして実現可能ならしめた斎藤報恩会に対して我々は茲に改めて深厚なる感謝の意を表する。

本実験所に於て実習及び研究に最もよく用ひられる動物はカキ *Ostrea gigas*, イワガキ *Ostrea nippona* (以前は *O. circumpecta* と誤認されたもの) 帆立介 *Pecten yessoensis*, 白ナマコ *Caudina*, ウニ数種, ゴカイ *Nereis*, ホヤ *Cynthia* 等が代表的のものである。

海洋定時観測等の外に所員は年中断えず研究を継続している。また生物学教室の職員及び学生も出来るだけ屢来所して此所の材料で研究をすることになつている。尚また、外来の研究者も出来るだ便宜を与え、歓迎している。来所の際は予め照会せられ度い。

本実験所で行つた研究殊に、小久保、野村、山本等によつて行はた研究は青森県の水産殊に帆立介増殖に科学的基礎を与えたものとして大いに感謝されている。

海洋観測 これは定常の仕事として、多年に亘り観測記録せられているから、場合によりては甚だ貴重な資料である。浅虫の海洋条件の一の例は次の如くである。

1926	最 高	最 低	年 平 均	備 考
気 温 °C.	23.4 (8月)	-0.62 (1月)	11.23	{ 青 宮 森 9.3 古 淵 10.9 新 12.6
海水温 °C.	22.83 (8月)	5.18 (2月)	12.91	
比 重	25.05 (9月)	21.71 (4月)	24.29	
塩 分	33.78 (9月)	29.43 (4月)	32.79	{ 黒 潮 26.50 親 潮 25.00 オコツク海 24.50
クロール%	18.70 (9月)	16.29 (4月)	18.15	
1953				
気 温 °C.	30.5 (7月)	-6.4 (2月)	11.34	
海水温 °C.	24.9 (8月)	5.39 (2月)	13.06	
クロール%	18.76 (3月)	15.67 (5月)	17.60	

出 版 物 本実験所で行はれた研究及び所員が他所で行つた研究は主に東北(帝国)大学理科報告第四輯(生物学)に発表されるが、時に他の権威ある雑誌にも発表される。終戦後はマツクアーサーの命で何れの帝国大学も帝国の文学を省くことになつたので理科報告も自然と帝国の文字を省略することになつた。浅虫からの業績は番号を附けているが、番号外のものも多数ある。番号を附したもののみでも最近では 200 を超え、参照の際不便になつたので、業績表とその索引とを作ることが切実に要請されるようになった。

また小久保所長時代昭和 21 年 1 月 1 日に本誌の前身「海洋生物時報」は困難の時代に謄写版刷として発足したのであつたが、事情の好転と共に本印刷となり、更に現所長の時代になつて、従来から用いていた英文名に対応して浅虫臨海実験所報告と改題し、また本文も英文を主にして広く海外にも配布することにした。尚本所から理科報告その他に発表された本所の業績の別刷を合本して、広く配布することになつてゐる。それ等と交換に我実験所は内外著名の臨海実験所その他の研究機関から多くの貴重なる資料を受けて居る。それ等は到底購入することの出来ない位のものが多いから、出版物の交換は単に学术交流のみならず経済的にも甚だ有利なやり方である。従つて更に多くの交換が望まれる。

擱筆にあつて、実験所業績報告の増加によつて、その業績表の印刷が必要となり、それを著者索引及び事項索引と共に此の巻末に附することを報告するのは我々の甚だ欣快とするところである。

追 想 録

浅虫臨海実験所の思い出

畑 井 新 喜 司

一生の最良部分を浅虫に送った私に取つては実験所はなつかしみの深い思ひ出の場所であり又学問的生活から見て第二の故郷であります。

創設当時から退官するまでの永い年月の間を追想すると数多き事柄が浮び出るのは当然の事であるが一言に縮めると楽しかつた年であつたと申上ぐるより外ありません。私は実験所創設に際して特に苦心談と云うものは有りません。計画の顛蹛や失敗もあつた事に気付きますが前途の希望に充たされた私には何事も愉快に又楽しみつゝ仕事に従事したので創設時代の経験は苦心でなくて楽しい思い出となつておるのです。

臨海実験所創設の任務を依嘱された時に第一に考えた事は生物学教室に接近したる適地に設くる事は最良と考えたので教室員(当時の野村益太郎助教授・村沢三二助教授・野村七録講師)と共に宮城県下の各所を調査した結果金華山に面する鮎川町附近と決定し地元とも了解を得たので愈々建設の準備に着手したが、突然地元民より大事な点に関する協定破棄の申出であつたので已むなく宮城県を思い切り直ちに福島・岩手・秋田及び青森の各県を調査した結果、青森湾に面する浅虫を選定したのであつた。

其当時実験所を建設する為めの条件として第一に交通の比較的便利なる事、第二は実験所の常住者家族の生活の便利と子供の教育が或る程度容易に行はるゝ事、第三は健康地帯にして研究者は無論の事家族も喜んで滞在出来る事であつた。以上三点が揃はぬ土地では永続性ある研究の実績を挙げ難きは従来各所の実例に照して、明瞭な事であるので以上の三点を或る程度具備したる場所の選定を考えたのである。生物学上必要な資料の豊富、採集地域の変化に富む事などを第一条件とする事は当然である。

浅虫が或る程度以上の条件に叶つたので、其の地を最終的に決定し直ちに建設の準備を進めたの

であつた。建設に当り当時青森県知事尾崎勇次郎氏、浅虫土地所有の平田義造氏と野村治三郎氏等の好意により、適当なる土地の寄附或其他幾多の便宜を提供されたので思つたより順調に建設の進捗を見た事は感謝に堪へぬ次第である。

実験所の建設費は拾五万円と記憶しておる。其他青森県より水族館の建設費として五万円の寄附を得た。唯だ大学の臨海実験所構内に公開の水族館を併設する事は研究を阻害し且つ実験所の品位を低くすると云う非難を受けたものであつた。然し私としては水族館は学問の普及に加えて学生が動物の生理生態方面の研究に欠く事が出来ぬと云う見地から既定の方針に邁進したのであつた。それから今一つの非難は実験所に四棟の官舎を設くる事であつた。つまり実験所建設費を削いて官舎を建設するのは研究施設を縮減する結果になると云うのであつた。然し私の考えとしては研究所の発展には研究員が喜んで永く滞在し、又気持ちよく研究に従事する事であるから研究者及び其家族が楽しく滞在期間を送る事は重要であるから多少研究設備費が縮減されても研究実績に於いて十分に上に補いが出来ると確信したので是れも非難に耳を傾げずに実行したのであつた。

此の際私の最も感誼しておつた点は、時の大学総長小川正孝博士が私の主旨に心から賛意を表せられ幾多の非難がありましたにも不拘私が自分の理想に邁進する様にと激励された事であつた。斯く千余曲折を経て浅虫に現在見らるゝ如き臨海実験所の完成を見たのは大正13年と記憶しておる。

其の頃生物学教室の第一期及び二期の学生は実験所が完成しておらぬので最初は東奥館分館の一室にて実習を行いそれから寄宿舍が出来上つたので夫れを利用して不便な実習を行つたものである。(註を見よ)

大正13年に実験所も完成したので愈々本格的な研究に着手した。研究項目も多数に上るが、今日

猶私の頭に浮ぶ楽しき想出は、白なまごの共同研究と陸奥湾の生物調査であつた。陸奥湾の調査は斎藤報恩会の補助により行われたもので、日本各地の専門家の協力を得て大仕掛な調査に従事し可成りの成績を挙げ得たのである。それからロッツフェラー財団の援助により生物学教室に迎えた、加州大学のコホイド教授、ミネソタ大学のマクレンドン教授、シカゴ大学のチャイルド教授及びオレゴン大学のモーア教授等を毎年一名宛4ヶ年に亘り浅虫に迎えて夏季講習会を開催した事であつた。日本各地の大学や高等専門学校の諸学者が参加せられ、有意義な而もにぎにぎし講習会の実を挙げ得た事などであつた。又津軽半島を巡歴して鉄魚の調査を行つた事や、学生諸君等とレクリエーションの爲め湾内の島々で魚釣をやつた事で是れは私にとり今猶忘れ得ぬ思い出の一つである。往年カナダで太平洋学術会議のあつた際此の魚釣に何時も参加したコホイド教授は学会の席上浅虫実験所で試みた魚釣の経験を講演中に加えて、参

列者の大拍手をあげた事を記憶している。

私としては大正13年に北海道大学より小久保清治氏を実験所に迎え得た事を特筆したい。同君は15年の永きに亘り実験所構内に居住し、発展と維持の爲めに努力された事は感謝に堪えぬ次第である。

長年月に亘る思い出を書き並べると際限ないので此処に終りの一筆附け加えたいのは、東北大学の臨海実験所を青森県の北端浅虫に選定した事がよかつたと今猶ほ確信しておる事と、実験所にて研究に従事された多数の研究者の熱心な努力に感謝申し上げ加えて現職員諸君の努力により今後益々実験所が発展せられ生物学の進歩に寄与されん事を心から切望する次第であります。

(註) 実験所完成前に東奥館別館で先生と一緒に研究したのは故野村益太郎教授と私とである。我々も若かつたので先生は学生と一緒に御記憶のようである。これは一期生にもたしかめたことである。(野村七録記)

東北大学浅虫臨海実験所30年の想出

小久保清治

私の実験所官舎在住は、実験所創立の大正13年春から昭和28年秋までのあしかけ30年間で、私としては生涯の中の主な部分を浅虫で過したわけである。

考えて見ると此の長い間毎日タタ実験室と官舎の間を朝昼晩3回と大体3万回千回か往復して暮した事になる。然し明け暮れ30年間の此の月日も過ぎては南柯一炊の夢で今更年ら白馬陳行の月日を数ぜずには居られない。

私は性分として一時でも何かせずには居られなたちで、実験室へ行けば直ぐ実験をするとか、文献でも読むとか兎に角長い間一生懸命やつたのであるが、それでいて仕事はさっぱり出来なかつた。迂鈍な話であるが然し私には発表しない仕事で時日をかけたものが沢山あり未完成のものが少くないので今でも沢山の資料をもっている。此は私の仕事には悪く言えば興味本位のものが多く、顕微鏡なども見はじめるとノートをとりはじめる前に唯だ覗いている時間ばかり多く、よい標本で

も出て来ると顕微鏡写真が始まつて2日でも3日でも之をやつている。然る後ノートを書きはじめるとどう具合で、そのかわりよい写真も大分とれて之は今後大いに役に立つと思つている。それから仕事をまとめたり原稿書いたるにも至つて遅筆でなかなか進まない。こんど各方面からの援助の御蔭様で出す事の出来た浮游硅藻類などもずいぶん長くかゝつた。それに原稿を一度は必ず清書する癖で之なども大分時間の不経済になるのである。

偕て昔からの話になると私が浅虫へ来た頃は畑井先生も未だ若く48才であられたと思うが非常に元気で夏やすみは無縁の事、春冬の休みにはずつと浅虫に居られ研究もされた。当時の想出の第一は先生の魚釣である。先生の釣好きは米国当時からで、ウィスターに居られた頃はたでは畑井が居なければ川へ行つて探せと云いたくらいだと自分でも云つて居られた。先生の釣も昭和始めの頃が絶頂で此の頃は朝昼晩と出かけたものであ

る。場所は大抵茂浦か双子でゲームは「そらふき」ときまつていた。私も釣は好きなのだが熱心の程度は逆も畑井先生にはかなわない。私のは野次気分だが先生は何時も緊張して深刻で獲物も大抵僕の二倍や三倍はあつた。盆踊りの太鼓を沖で聞き乍ら月の夜遅くまで釣つた事もあつた。

釣の外に私は浅虫で狩猟もやつた。モーターで湾内を乗りまわして海鳥を採集した。之は狩猟の興味と云う事からでもあるが、一体海鳥は非常に種類が多く青森湾だけでも何十種と居る。それでいて誰も一向注意しない、此の点から採集を始めたのであつた。海鳥の渡来は10月からで2月3月頃に最も多いのであるから沖は寒いのであるが辛棒よく出かけ1日百発も打つた事があつた。御蔭で標本も四、五十種は集まり、其の種名は皆黒田長礼博士につけて頂いて標本室に陳列したのであるが、今標本室に残っているのは其の当時のものである。8月に沖で「いるか」を追ひ、とうとう一尾をしとめた。散弾銃で「いるか」を打つなどはうその様な話であるが、此の「いるか」をいま能生の水産高等学校の校長をしている野中君が其の頃助手で解剖して呉れ腸の長さを計ると23米あつた。

当時から今日までの30年間にはずいぶん世相の変化もあつた。大正から昭和の始めの頃は第一次大戦のあとで、人心が頂度此の頃の様に弛緩していたので実験所附近に度々男女の身投げがあつた。若い同志がしごきで体をゆわいて投身したのや、娘の一人自殺や、他殺と思われる猟奇的の事件や、投身したが死されず夜半にびしょぬれになつて実験所の戸をたゝいたのや、此の様な事が十の指を屈する程あつた。日支事変が進むに従つて人心も緊張し此の様な事は全くなつたが、戦後また始まつた。昭和23年11月8日はじめてストーブをつけた日で頂度野村教授が私の室に居られた時其の日の時化の最中20才になる青森娘が投身した。非常に寒い日で救い揚げた時は手足は氷の様だったが私が人工呼吸を施すと蘇生した。此の娘はあとで父親といつしよに菓子折をもつて御礼に来た。

戦時中には横須賀から海軍が疎開して来るし、水族館は閉鎖するし、臨海実験は休むし、小使や助手諸君も応召するし、昭和18年には一時私一人きりになつてしまつた事もあつた。昭和20年の終戦の年には浅虫の爆撃があつて艦載機が実験

所の真上にやつて来て湯の島の西側に待避中の陸軍の輸送船をそれから茂浦島の北側にかくれていた連絡船を爆撃するので一日中防空壕から出られないと云う事もあつた。

実験所が爆撃されなかつた事は実にしあわせな事であつたが、何せ爆弾は前後の海へ無数に落ちては爆発したので窓硝子などは一枚もなくなつてしまつた。其の上水族館は二年も閉鎖していたので水槽は破損するし、御筒は動かないし、戦争が済んで見ると実験所は手のつけ様がない有様だつた。一方仙台でも大学の被害が大きいので相談に行つても浅虫どころではなかつた。また青森は青森で一面の焼野原になつていたので何の用事も足りない。それでいろいろ考えた末当分復旧にも着手出来そうもないから皆で相談し、一応窓硝子だけでもはめて当分はだまつて顕微鏡でも見てうんと勉強しよう云う事にして朝から晩までブランクトンを見た。海洋生物時報と云う謄写報告は此の時はじめたのである。

然し何時までもこうしても居られないので21年後半期から復旧運動を始めた。当時水族館の修理だけで最少限度50万円を要すると云うわけであつたが学校の方には予算は全然ない。それでやはり之は地方で金をあつめるより外はないと思ひ地元の野内村や青森県庁に百万懇請して協力して貰う事にした。幸いにして当時の副知事松野伝氏それから現知事の津島文治氏が青森県としても困難な財政の中を特に実験所の為めに考慮して下さい20万円の寄附を承諾された。之が呼び水になつて地元の野内村も同じく20万円の寄附を決定して呉れ、都合40万円の予算が出来て学校から10万円ばかり出て23年度の春から復旧工事に着手する事が出来た。簡単に云えばこうであるが此の為めには県下をずいぶん走りまわつた。当時の県の水産課長の諏訪さんも非常に同情して私の無力を助けて呉れ、いつしよに方々をあるいて呉れた。実に有難い事だつた。忘れもせぬ22年の2月24日大吹雪の日に2人で有力者某を尋ねて協力を御願ひしたが其の人はストーブの向う側に背中を向けて座たまゝこちらに向かず吾々を失望せしめた。

然し兎も角青森県当局及び県民各位の協力の賜として23年4月に着工した復旧工事は7月中旬に竣工し8月1日には水族館も目出度く開館された。ところが茲に困つた事は戦前と違つて予算に

収支辨と云う事が出来なくなり、実験所に前渡金と云うものが無いので水族館の魚を購入する事が出来ない。学校へ相談に行っても文部省へ行っても事情はわかっているが規則はどうする事も出来ないと言ふ。そうすると理学部の或人が来てそれはしかたがないから入場料の一部をためて取つて置いてそれを使いなさい。それは第二予算と云うので帳簿は別にこしらえて正しく収支をつけて置けば差支えないと云う。これはよい事を教わつたと思つて其の通りにしていると、これが中央に了解がついて居なかつた為め会計法違反だと言ふので事務局長から大目玉を食う事になった。しかし私は実験所としてはこうするより外はない事を繰り返した。そこで学校でも放つて置くわけにも行かなくなり、其の結果実験所に財団法人の東北大学臨海実験所後援会と云うのを作り水族館は此の財団が経営すると云う事になった。此の設立も事柄は大分めんどうでいろいろ苦心したのであるが現会計課長の板谷さんの非常な骨折りと、それから現北大水産の助教授の川村輝良君が非常に働いて呉れるにせよ、之に就て忘れる事の出来ないのは当時の理学部事務長で今は故人の山本順恵氏が大変骨を折つて呉れた事で之等の方々の尽力の結果昭和25年4月28日に財団の登録が出来て、之から水族館の経営は一切此の後援会で行う様になった。幸い此の後水族館運営の経過は至て順調で年々入場者も増し施設も改善されて今日に至つた次第である。

実験所の研究方面としては大正13年以来いろいろの研究が行われた。創立から4、5年の間は陸奥湾の生物調査時代で畑井先生の最も熱心に指導監督された時代である。之は生理をやるにも生態をやるにも動植物の種類がわかつて居なければ問題にならぬと云う事から、先ず動植物を採集しそれを各専門家に委嘱して分類を研究して貰おうと云う事になった。畑井先生が此目論見を立てられたのは大正14年であつたが翌15年に故朴沢教授と田原兩教授と小生との3人の共同研究と云う事にして、当時畑井先生の会長であつた斎藤報恩会から5千円の研究費を貰ひ、15年と昭和2年の2ヶ年間はモーターボートで盛に陸奥湾内でドレッジを曳き標本を採集した。故飯塚啓、丘浅次郎、岡村金太郎等の諸先生が来所研究されたのも此の年の8月であつた。野辺地湾の採集で朴沢教授と小生とが間違つて大湊の芦崎湾に入り海

軍に抑留されたのも此の年の8月11日であつた。

此の頃から昭和4、5年頃までは「かき」と「しろなまこ」の生理生態が盛んに研究され之に就ての論文が相次いで発表された。「かき」と「しろなまこ」は今後も大いに研究さる可きものと思ふ。昭和5年にはカリホルニア大学のコホイド教授が7月に来所され原生動物学の講習会が開かれ各大学の教授、助教授、助手等廿余名が講習をうけた。同7年にはマックレンドン教授、8年にはモア教授が来られ学生を指導し研究もされた。

それから昭和6年には5月に畑井先生の主催で学術研究会議で日本全国の沿岸のプランクトン研究をやる事になり、主として浅虫で小生が研究を引き受ける事になった。此の研究は昭和6、7、8の3ヶ年間に全国各地の沿岸15地点で採集したプランクトンを学術研究会議のプランクトン時報に発表する事であつたが結局仕事は昭和15年まで続いた。また一方昭和7、8年から、やはり畑井先生の発案で鯨の刺戟生理の研究が始まり仕事には主として当時の助手の阿部襄氏があたり、当時の野村助教授、小生なども一端を担い大分興味ある研究が発表された。其の顕著な一例は鯨の体は百平方センチマイクロアンペアぐらいの電流を尾の方から流すと此の魚の振動的刺戟に対する感度つまり被刺戟性がたかまり、電流が断たれると直ぐそれがなくなる事などであつた。また鯨のクロナキシーも研究された。

プランクトン時報の最終号が出たのが昭和15年であつたが、実験所としては創立以来所長として15年間も指導された畑井先生が昭和13年に停年退職され実験所に一時期を劃した。此の後は教室の各教授が2年交代で所長を兼任される事になった。それで故朴沢教授、同じく故野村(益)教授それから現所長の野村教授、次に昭和22年から不肖が所長を拜命して昭和28年に至つたが、小生停年退職後再び野村教授が所長に就任されたわけである。然るに畑井先生がやめられて昭和15年頃になると日支事変は大東亜戦争に入らんとする直前で、此の頃から社会状況は大分に変化し人心は緊張し物資は欠乏して来て此の勢は実験所にも波及しガソリンは無くなる、モーターボートは腐朽する、予算はつまつて来ると云う事になった。そこで考えて実験所の研究は顕微鏡一本だけで行く事にした。昭和17、8年は困難の絶頂で前に述べた通り水族館も閉鎖すると云う事になり

20年8月の終戦を迎えたのである。終戦後も昭和24年迄は研究はプランクトン及び海洋状況を報告する事にとどまったが24年からは青森県の水産資源調査が始まり、実験所も此の一端を担つて鱈の生態調査、帆立の増殖研究、それから海況調査などが行われる様になり爾後凡てが常態に復して今日に至つたわけである。

何にせよ30年間と云えば長い間であるからいろいろの事があつた。創立の当時は畑井先生も40何才の若さで実験室の指導にも茂浦の磯採集にも潑刺たる元氣であたられ心強い限りであつた。野村(益)教授は実験所とは縁のうすい方であつたが、朴沢教授は物故されるまで連年学生の指導に來られた。現所長の野村教授も当時助教授時代で今の白髪も其の頃は漆黑オールバック型で元氣なものであつた。創立以来今年まで一年も欠かさず來所されたのは野村教授だけである。それから元村教授も大体其の頃からで其の名の如く教室及び実験所の元勳であるが昔から精励強記当時既に氏の今日あるを思わしめた。

考えて見るといろいろの事があつた。K君が官舎で盲腸炎を起し二晩も唸つて皆を心配させたり、M君がジフテリアにかゝつて青森病院に入院したり、Y君が蝨に指を咬まれて神病院に入つたとか、K君が芸者に想われたとか、I君がスキーで御尻を割れたとか、I君と云えば此のクラスには今東京にいるH君だの当時北大から來ていたM君だの頭のよい頓智諧謔の輩がそろつていて人に綽名をつけた。S君と云う助手がいた。彼は顔が細くどうやら狐の感じである。盆踊が好きで郷里が静岡で余興によく串本節を唄つた。之には「くしもとぼんだんぎつね」なる和名がつけられた。之には感心した。A君はやさしい人で話声が小さくそれで毛深い人であつた。当時「かたつむり」の殻をあつめていた。此の和名は「けぶかかなきまいまい」と云うのであつた。ストームをやつて寄宿だけでは足りないで官舎の方まで練つてあるいた。

昭和10年11月7日に実験所の直ぐ裏に7尺もあろうかと思われる大きな「おつとせい」があらわれた。鬚の見えるくらいの所まで來ているのでモーターを出して追かけ写真もとつたが船が近づくと急流を流れるように早く泳いで沖に逃げてしまつた。

昭和11年10月には空前の大時化があつた。

氣圧が718「ミリ」に下がり風速50米突を計つたと思つたら風速計が飛んでしまつた。実験所の護岸は正面を残して殆ど全部破壊されてしまつた。早速文部省に復旧費を要求し5万円の予算を得て12年の春に構内全沿岸のコンクリート工事を完成した。今の立派な護岸は此の時出來たのである。堀井管轄課長の時代であつた。其の後昭和26年に裸島へ渡るコンクリートの一間半ばかりの小橋をかけたところ其の経費が5万円であつた。金の値打も昭和12年から26年までにこう變つたのである。

30年の間実験所の西窓から青森灣を眺め暮して感じた事は海岸では少しでも風があると直ぐ波が立ち10米突の風はもう磯船には時化である。すつかり風いでのおんぴりと氣の落ちつくのは風速零か一米突以内の時だけで此の様な事は5、6月だけである。此の点海辺は落ちつきがない。山や内陸の様な静けさは殆どないと云つてよい。海辺では毎日の気分は全く目に見る浪風に支配され、天候ばかり氣にしながら暮す事になる。然し淺虫では官舎が山の裏手にあるので浪を見ずにも暮せる。たまに静かな雪の夜などには連絡船の霧笛がかすかに枕辺に聞えて來る。暖かいストーブのそばで今日の実験の事を考え乍らジョニオカの一杯もかたむけ偕て夢路に入るのである。

忘れられないのは官舎のあたりの自然と其の四季である。1月から2月雪の深い頃よく白鳥の一連が空をかすめて飛んだ。早い頃には玄關の軒に山鳥が尾を下けてとまつている事もあつたし、猿小屋の前に高さ四尺ぐらいの大鷲が下りた事もあつた。兎も官舎の囲りに來るし、寒中でも静かな日には雪の上に出て遊ぶ「りす」もあつた。此の「りす」は私の食事をする1時間ぐらいベランダの手すりに遊んでいた。小鳥の爲めに作つた庭の巣箱には「りす」が子を産み子供は毎日巣箱の外に出て遊んだ。此の巣箱は雀や四十雀の巣になつた事もあるし、大熊蜂の巣になつた事もあつた。官舎の寒中の小鳥は「うそ」でこれが桜の蕾を食うにはよわつた。

3月頃海の風いだ日には沖で氷鳴の鳴く聲が笛の様に聞えた。之から4月は海鳥の帰北で水際には「あいさ」が沢山來た。官舎のまわりには、3月に先ず落のとうが芽を出し、一輪花が咲きはじめ、次いで「かたくり」が咲く。此の頃山には「まひわ」の可愛い鳴声が聞え官舎の前には「く

ろつぐみ」が来る。地面に下りては餌を拾ひ木の上にあがつて鳴く、これが此の鳥の習性である。之から6月まで何十種の小鳥が来るのであるが、私は小鳥日誌をつけて彼等の去来をすつかり記録してある。鳴鳥としては何と云つても「くろつぐみ」で春の末「きびたき」「大るり」「三光鳥」などが来る。「きびたき」はよい鳥で「くろつぐみ」に次いで毎年必ず来て池の周りの若葉の中で啼く。時々オーシツクツクオーシツクツクと啼くのがたまらなく可愛い。時として官舎の窓際まで来て美しい姿を見せる事もあつた。夏には「やぶさめ」が虫の様に鳴き、珍らしいものでは「ほしがらす」が大群をなして来た事があり、官舎の下の方の池には夏遅く真赤な「みやましようびん」が来て夕方明方に悲しい声で啼く。之を聞くと八甲田の山奥に入った様な気がした。寄宿の下水の下の方の藪は何時も湿っているので此処に初夏に「こよしきり」が来て啼いた。よくこう云う所をさがすものだと思ふのであるが、これつばかりの湿地が彼等には水郷の様にでも思えるのだ

ろうか。

夏はどこも同じで小鳥は少くなるが「ばん」や「くひな」は遅くまで鳴き、「せんだいむしくひ」「さんしよくひ」など八月中も鳴いた。七月中頃から啼く「鯛」もなつかしいもので官舎で毎年此の啼くのを待ったものである。月中頃から此の啼かなくなるのが淋しかった。

秋には夜ふけに「ふくろう」が鳴いた。明け方まで鳴く事もあつた。夜半に目をさましてふくろうの鳴くのを聞くと如何にも山の中と云う感じがしてよいものである。秋も月初めには「こがら」「ひがら」が暫く鳴きしきる。10月いつばいで水族館をしめて西風が強くなる頃は鴨の渡りで沖には「しのりがも」「すゞがも」などが来る。少し遅れて「まがも」「くろがも」「きんくろ」などが渡来する。此の頃から実験所附近は木葉悉く脱して朝夕の寒さも漸くまさり、ストーブをつけ冬囲ひをして越冬に入るのである。浅虫の四季のうつり変りはなつかしい。何につけかにつけ浅虫の自然を想い出す。

浅虫臨海実験所の思い出

高 槻 俊 一

浅虫の臨海実験所が創立されてから30年。去る8月に盛大な記念祝典が行われ、私もその席に列することを得たのでした。顧みれば、実験所が創立されてまもない頃、大凡3ヶ年実験所に居りました私には、その頃から既に30年もたつたのかと思つて全く夢のように感じた。それで私が浅虫実験所にいた当時のことを思い出そうと筆をとつてみたのです。私が浅虫の実験所に初めて行つたのは、残雪も未だ深い大正13年の初春であつたと思う。それは畑井先生御指導のもとに行われた第一回生物学科の学生の臨海実習でした。当時は実験所も未だ落成せず創設工事が行われていたので、実験所の研究室は使用されず、寄宿舎の食堂を実験室として実習したのでした。海岸は積雪もあるので採集も行けず、毎朝プランクトンを曳いてはそれを一日中顕微鏡でみながらスケッチ

したのを思ひ出すのです。一週間位の期間であつたと思う。特別に変つたこともなく皆んな愉快に実習したことでした。唯私にとつては忘れることの出来ないのは、この時に畑井先生がカキの心臓の御研究をされていたことである。それは私が翌年卒業論文のテーマとして先生から頂いたものであり、その後も引き続いてこの研究をしている私にとつては感銘深いものです。

間もなく陸奥湾の一角無人の境とも云うべき海辺に、当時としては注目されるような赤レンガ造りの立派な、臨海実験所ができ上り、大正13年の7月に盛大な創立記念式が行われた。当時私は3年の学生としてこの式に参加することが出来ましたので、いろいろの記憶が残されているのです。当日は小川総長をはじめ、多数の諸教授が仙台から来所され実験所側からは畑井先生及び教室

の諸先生が列席され、更に地方の人々が加わり実に盛大な開所式であつた。その時に畑井先生が実験所の目的に就いて御話しになつた中に、なお記憶に残るのは学問の至上主義であつた。

かくして当時としては国内に於ては最も完備した実験所として出発したのでした。当時は前述のように私は三年の学生で卒業論文の実験をするために、その年の4月から12月頃まで実験所に居たのです。その後教室を卒えてから助手として実験所に勤務するようになったのが翌年の大正15年でした。それから満2ヶ年浅虫の実験所で研究を続けることができたのでした。その間にいろいろなこともありました、特筆すべきことは陸奥湾の生物調査でした。これは畑井先生が主宰され実験所が現場中心となつて陸奥湾の生物相を調べることでした。ぼうまでもなく、実験所としてその近海の生物相を知つて置くことは重要なことで、先ずこの研究に第一歩をとつたものであつたものと思ひました。当時は教室の諸先生をはじめ、日本の海産動物学者としては、一流の諸先生がたが

実験所に来所されて陸奥湾の生物に就いて、研究された。私もその一員に加えられ専心陸奥湾の生物採集に従事しました。御蔭でそれらの諸先生に親しく接することができて大変にいろいろと勉強になりました。殊に現在多少なりとも海産動物の分類学的知識を有するのは、全くその当時の賜物であると思つてゐる。

なおこの陸奥湾生物調査は当時としては、全く劃期的なもので、その結果は東北大学理科報告に続々発表され学界に多大な貢献をしていることは周知のようです。またこの調査中には種々のエピソードもあつたのですが、それは他の機会に譲りますが、実験所としては当時が最も活気のあつた一時代であつたと思う。その後も多くの研究者が実験所を訪れて種々の立派な研究成果が多数に発表されていることはいうまでもないことです。

浅虫実験所創立30週年の記念祝典に列席し創設当時の思い出の一端をのべ今後実験所の益々発展されるのを祈りつゝ筆をおきたいと思う。

悪 童 の 手 記

永 野 為 武

浅虫臨海実験所とわたしたちのつながりは、1930年の6月を機とする。想えばちょうど4分の1世紀前のことである。

わたしたちは、今でも1930年の21日間の寄宿舎生活に、多くの回想を抱くのみか、深い感謝の念をもっている。わたしたちは、その共同生活によつて、生涯の緊密な結びつきを得たからである。

はじめて一行が浅虫の駅に降りたつた日の光景が、まざまざと蘇つてくる。20馬力のモーターボートが潮風を切つて実験所前桟橋に着く。畑井先生、小久保先生の出迎えをうけて実験所の門をくゞつたときは、ウッズホールにでも留学したような気分であつた。

プランクトンの実習は、ロックフェラー財団の派遣教授コフォイド博士の直伝で、双鞭毛虫に関しては、一躍世界最高の水準に達した気持であつた。わたしたちは得意であつた。北大の元田茂君も、この時、この実習に加わつたので、はじめか

らの級友のように親しくなつた。朴沢先生に愛せられたわたしたちは、浅虫小学校にでかけ町の人と野球の試合をして面目をほどこしもした。また、招待する大会では、遠藤英夫君が8はい(伝説では12はい)の不朽の記録を樹立した。留さんにも、わたしたちは可愛がられたのである。

かくて、わたしたち悪童どものなかから、秘聞がいくつも生れた。たとえば、石田周三君はアメフラシの卵塊をなまでくつて腹痛をおこしたとか、寄宿舎のある早朝、砲丸を廊下どころがし、先輩の部屋に陳入して枕をとつて暁の夢を破り、渡辺勇さんに大へんしかられたとか。また、夜ごと悪童の一人が○教育の連続講義をしてくれるので、わたしのごとき清浄無垢の精神の持主が、急に○○○○をするというようなぐあいである。

いまにして告白すれば、わたしたちの合作になる浅虫音頭の節は、あの卑猥な鍋島節の音曲をそのまま伝えるものである。

1. ゆられゆられて浅虫下りサイサイ

- 21 日ドンガラガンノガン籠の鳥セツセツセ
籠の鳥セツセツセ
2. 東恐山、西には岩木サイサイ
波間がくれにドン……蝦夷ガ島セツセツセ
蝦夷ガ島セツセツセ
3. 赤い煉瓦に白衣の動くサイサイ
水にうつるはドン……裸島セツセツセ
裸島セツセツセ
4. 怒濤さかまく波乗り越えてサイサイ
今日も明日もドン……ブランクトンセツセツ
セブランクトンセツセツセ
5. 今日底曳湯の島あたりサイサイ
獲れたえものはドン……こじきのまらセツセ
ツセこじきのまらセツセツセ
6. 午後はエビ網、鷗島沖でサイサイ
エビは一樽ドン……釣の餌セツセツセ
釣の餌セツセツセ
7. うちのおやじは、釣竿肩にサイサイ
20 馬力でドン……茂浦島セツセツセ
茂浦島セツセツセ
8. 白いバラソル岩角巡りサイサイ
拝む地藏さんはドン……縁結びセツセツセ
縁結びセツセツセ

事実、当時の水族館には楚々たる美人が陸続として出現し、全国唯一の国立地蔵尊堂には紙よりの束が花のごとく咲いていた。また、比較形態学的見地から、元村さんとウマツラハギの相似についての論も行なわれたし、後日、わたしたちが生物教室を卒業してから発行した33会報には、当時の某先輩で、ホモ・ロンギベニスなどという学名で記載された方もある。

次の年は2年の学生として動物生理学の実習である。小林佐太郎さんが目をばちばちさせながら、悪童どもの相手をされた。ある日、閑院宮元帥が実験所にこられるという。ちょうど魚の鰓蓋のバクバク運動をキモグラフに描く実習であつた。それこそ、わたしから咫尺のところに帝の宮様がたたれ、畑井先生が説明役としてならんでおられた。

「魚が横にねせられているが、立て、描かせても同じか」という質問であつたことを、はつきりと記憶している。翌日の『東奥日報』には、1年の実習では、朴沢先生が説明の役をなされたことと、「余はナマコには骨がないと聞いていたが、ナマコにも骨があるか!」と大へん感慨深く骨片を

顕微鏡下に、おのぞきになつたという記事を読んだ。世が世であつたので、大いに感激したのである。

卒業実験を臨海実験所で行なうもののあるのは、当時のならわしであつたし、卒業後も引続いて止まるものもあるわけだつたが、同級では、そうした宇塚清、石川清雄の両兄が、いまでは幽明境を異にしていることは、まことに淋しい。また1年の実習が終つて北海道に旅行し、その地で腸チフスにかかり、あやうく一命をとりとめた太田操作君が、昨年の暮、不治の病にたおれたことも浅虫との関連があるだけに悲しまれてならない。

その後、しばらく浅虫とわたしとは縁がないかにみえたが、1942年から7年間、野村七緑先生の生理実習のお手伝で、毎夏、2年の学生諸兄と起居をとにした。戦の進むにつれて、寄宿舎の食事は量も質も低下するばかり。かつて日毎ホタテの貝柱のテンブラで下痢をした学生時代をなつかしむの情切なるものがあつた。しかし、わたしたちにとって幸であつたのは、ミハシ亭がだしてくれたウドンで。箸のたたない、おかゆの朝食では11時すぎには早くも気が遠くなり、それで早目に実習のくぎりをつけ、ミハシ亭にかけこんだものである。呼吸の実験に使つた水族館の魚や実習後釣して得た魚は、すべて夕飯の食卓に登場して、わずかに空腹をいやし得たのも、これまた今は昔の物語である。

戦が終つて次の夏。水族館のガラスはやぶれ、湯島の前には、鉄船が赤腹をさらして青森空襲の日のはげしさ、日本の敗戦をまざまざとみせつけられたことも永久に忘れることはあるまい。

昨年の夏、臨海実験所30周年記念には野村先生よりの特別のご配慮で式典にも参加させていだいた。畑井・小久保両先生は嬰鑠として壮者をしのぐものがあり、高槻大先輩はじめ多くの先輩とともに往時を回想できたのは、なんとも幸であつた。この式典で、浅虫の小学生の一群が、道路や水族館前の清掃の労に對して、実験所から大きな大きな表彰状をおくられたとき、わたしは不覚にも涙を流してしまつたのである。

すでに定められた紙数を越えてしまつたが、なお敢て附記したいのは、昔の悪童の一人であるわたしが、次の日浅虫中学校で記念講演という大役を与えられ、滂沱たる汗を流したことである。

(1955年3月19日記)

臨海実験所の誕生

野村七録

大正13年7月5日東北帝国大学附属臨海実験所は浅虫に於て盛大なる開所式を挙行政した。それまでのいきさつを記憶をたどつて書いて見度い。

教室の創設費は幸に議案も通つて、当時としては日本中最も近代的な生物学教室が出来たのであるが、実験所の予算獲得はかなり難航をつづけた。

或る時は会議室で一同沈痛な顔をして相談をつづけたが、畑井先生は臨海実験所のない生物学教室等は面白くない、意味がない、予算が出なければアメリカに帰る等と御仰つたので一同益々憂鬱となつてしまつた。その時、会議室の隣の畑井教授室(今の私の室)の電話のベルが鳴るので誰でしたか、出て見たところ、本部からの連絡で実験所の予算は通過したとの知らせだつたので一同思わず歓声をあげ、急転直下会議室の空気一変し、まことに劇的な場面であつたことを忘れることは出来ない。これよりさき、畑井先生はじめ吾々は臨海実験所敷地の候補地を探し廻つた。前半は故朴沢教授と共に宮城県下を歩き、後半は故野村益太郎教授と共に青森秋田県下にもでも足を伸ばした。南は鳥の海、荒浜、莒蒲田から松島湾内各地及び渡波を廻り、更に志津川、女川、鮎川方面に及んだ。鮎川と大原湾の間の小淵と称する小湾は、細長く深く湾入し、湾奥は泥深くて三味線介を沢山産するので面白く、湾外には無数のウニが見られたので甚だ有望と判定された。地元では土地5万坪を寄附するから実験所を建ててくれとのことであつた。ところが我々が大学に帰つて間もなく地元の代表が仙台に出て来て、対岸の捕鯨場は永らくの休業で、今後も事業はしないと云う約束で候補地にきめたのに、前約をくつがへして、また捕鯨をやるから承認して貰い度いと云い出した。これはテツキリ補償金でも欲しくて来たものと思われたので畑井先生も大いに怒られて、早速候補地取消となつた。然し敷地は小淵と予定して創設費予算も要求してあるので、急に代りの候補地を探さなければならなくなつた。現在ならば女川も開けているが、当時は仙台から女川に行くには、先づ東北本線を小牛田で乗り換へて石巻に行き、そこから輕

便鉄道で渡波行きとなり、更に船で万石浦を渡り、女川寄りの岸に上陸して、今度は馬車でトコトコと女川へ行くのであつた。これでは地図の上では近くても交通は甚だ不便である。それで更に足を伸ばして気仙沼に行つたが、一ノ関からの鉄道は未だ通らず、タクシーをやとつたら片道40円をとられた。気仙沼は候補地としては面白いところもあるが、仮に現在300倍に値上りしたとしても片道12,000円かゝるのでは断念せざるを得なかつた。そこで、東北帝国大学だから、東北の海岸を広く公平に調査して何処でもいゝ所を見出すべきだ云う理屈が出て、先づ陸奥湾内の浅虫に目をつけた。浅虫は種々の動植物にも富んでゐるし、内湾で波が静かで小舟での採集も容易であるし、距離こそ仙台から遠いが東北本線で直通だし、急行も停るから交通は便利である。その点是小淵等は比較にならない。必要とあれば、精密機械でも高級薬品でも電報一本で仙台から確実に翌朝は浅虫で手に入る。最有望となつたのであるが、畑井先生は小湊、私は野辺地出身で二人の郷里に近い所を選んだと思われては申し訳ないので、此点は第三者である野益さんの判断を聞くことになつたが、野益さんも浅虫が一番いゝと云う。尚、念のために秋田県の海岸を見ようと云うので船川港を調査したが、何しろ石油の産地で海面に油が浮いて生物相も貧弱らしく候補地の資格なきものと認定した。ところで、旅行中、会計は私が扱つていたが、秋田に着いた時に宿屋の名も知らなかつたけれども、田舎のことであるから一番いゝ処へ行つたら間違なしだろうと思つて車屋に左様命じて車を連ねて乗り込んだのは、石橋だるま館と云う大きな宿で、当時仙台にはそんな大きな宿屋はなかつた。玄関には大きな沓脱の石で、便所の壁は櫟の一枚板、夕食になつたら一人一人に小い七輪に帆立介殻で白魚だつたかを煮てくれるので、これでは出張旅費では間に合うまいと会計係の私は内心大いに心配したが、翌朝支払となつて思ひの外に安かつたのでやつと安心した。話が戻つて浅虫になるが、湾内を舟で採集したのみか、汽車で小湊に行き、そこから、浅所附

近の干潟の調査をした。折柄未だ春先で川口の雪どけの水が踵を没し足のつめたいこと甚しく、こんな処で5分間だつてグズグズしてられるものではないと思つたが、何しろ畑井先生が真先になつて歩き廻るのだから仕方がなく、彼は一二時間引張り廻されて帰つた。夕食後畑井先生は御承知の如く早く御寝みなつたからいゝが、我々二人は時間が余つて仕様がな。縁側には採集して来た新鮮な陸奥湾の珍味ホヤがあつた。野益さんはホヤには口のない方だから、これで一杯やろうちやないかとぶうことになつた。私はどうぶう訳かホヤが食べられないのでホヤの方は何かで代用して、一杯の方を御つきあいし、二人で少しメートルを上げたらしい。畑井先生は一つ間を隔てて御やすみなつたのだが、翌朝先生は、昨晚何処の室だか矢筈しくておそくまで眠れなかつたと御不満のようであつた。我々二人は笑ふに笑へず恐縮しておつた。

さて裸島に向つた尖端のあたりが敷地によかうと云うことになつたが、宿の東奥館主平田義造さん(当主直司氏の御祖父さん)に来て貰つてきゝたところ、野辺地の野村(治三郎)と自分の共有地だとのことであつた。そこで先生は私に野村治三郎(私の従兄で本家)の意向を聞いて来いと云うことになつた。当時本家は政友会の陣笠で東京に家を構へて居たので私は早速行つて意向をたゞした。従兄は大学で御人用なだけいくらでも御とり下さいとの快諾を与へたので私はその通り復命したのであつた。寄附の手続きその他に就いては、県が間に入るか、或は個人直接の寄附にするか等の問題があつた。私はその後の詳細を知らなかつたがどうぶう訳か、寄附は実験室の敷地と官舎寄宿舍の敷地と離れて二ヶ所になつてゐた。ところが会計検査院の御役人が来る頃になつて、遠くはなれた艇庫は私有地に建つて居ることがわかれれば叱られると云うので、あわてて現在の如く全部を含めて一体とした広い敷地を寄附して貰うことになつた。その時も私は奥に行つたが、従兄は青森の政友会支部大会前で田舎の陣笠何人かと酒を飲んでゐたのを無理矢理引張つて来て現場に立ち合せて区域を定めた。それで敷地と境界には処々に石の標柱が建つてゐるから、これからの所員の方々はよく覚えて置いて頂き度い。

こんな具合で兎に角実験所の工事ははじまり、大正13年の春休みに未だ実験室の完成しないの

に畑井先生は第一回生を引伴れて乗り込み、寄宿舍の食堂で実習をされたそう。私はその時は教室の方で留守番をしていたが、その時米国帰りの助手が着任勾々チブスのため一週間計りで大学病院でなくなつたようなこともあつた。

実験所常住の助教授として小久保さんが北大から迎えられ、浅虫に着任したのは開所式間近の暑い日で、出迎の駅頭の風景が思い出される。

県や地元で協賛会を組織して開所式並びに祝賀会を盛大にしてくれたのは嬉しかつた。明治天皇が東北巡幸の際御休みになつたと云う千疊敷の広場に天幕を張つて式と祝宴が行われた。大学からは各学部長や評議員の方々も御来会になつた。法文学部長佐藤丑次郎先生は御酒の好きな方だつたが、少し召し上つたと見えて御機嫌で水族館に御出でになり、大きな水槽に威勢のいゝ大鯛が悠々と泳ぎ廻つてゐるのを見られて、「これで一杯やたらいいだろうな」と云われたのを未だに覚えてゐる。

実験所その後の発展は御承知の如く順調に進んだが、唯一つ困つたことは、淡水が不足なことであつた。そこで地質教室の矢部先生に御願して清水三郎君に出張調査させて頂いた。そこで実験所から廿町もはなれた屋敷山の谷間から当時八千円と云う大金をかけて水道を引いたのである。

実験所の設計は工学部の小倉強教授の手になるもので、工事は管轄課直管だから、課員は椿旅館に泊つてゐた。国道から入つた部分の道路は浅虫の青年団の特別奉仕によつて出来たもので、それまでは道路らしいものはなかつた。官舎一戸は5,000円を費したと聞く。物価騰貴の当時でも高いとされたが、何しろ材木は舟で運び、あの山を一本一本担ぎ上げたのだから、左もあらんと思われた。地方の人々はハイカラな家として見物に来たものも多かつたそう。その頃東奥館は一泊2円50銭位と記憶している。此頃よりも夏は暑く冬は寒かつたように思われる。

30年の星霜を経たのだからその間には色々の事もあつたが創立以来の人も代つて、今は森留君一人が財団の方に勤めているのみである。当時若かつた私も、今は停年を鼻先に控えて七代目の所長を承つてゐる次第である。思い出は次から次へと書けば尽きないのだが紙数も予定を超過するので、実験所の永遠の発展を祈つて此辺で筆を擱くことに致します。

東 北 大 学

浅虫臨海實驗所業績目錄

自第1号至第217号

(1924~1955)

LIST
OF
CONTRIBUTIONS
FROM THE
MARINE BIOLOGICAL STATION
OF
ASAMUSHI
TÔHOKU UNIVERSITY

NOS. 1 ~ 217

(1924 ~ 1955)



Asamushi, Aomori Prefecture

JAPAN

東北大學附屬臨海實驗所

青 森 縣 浅 虫

Contributions from the Marine Biological Station of Asamushi have appeared mainly in the Science Reports of the Tôhoku (Imperial) University, 4th Series (Biology). Earlier contributions, however, might not or confusedly be numbered. Numerous other contributions, not listed here, have also appeared in the Science Reports and various other journals, foreign and domestic. The General Index of the Science Reports, Vols. I-XX, (1924-1954), now in preparation may be useful to find their location.

Numbers in bold type refer to the volume number, numbers in parentheses to the issue number, and hyphenated numbers to page numbers.

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